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URBAN HIGHWAY STORM DRAINAGE MODEL

VOL. 6 ANALYSIS MODULE

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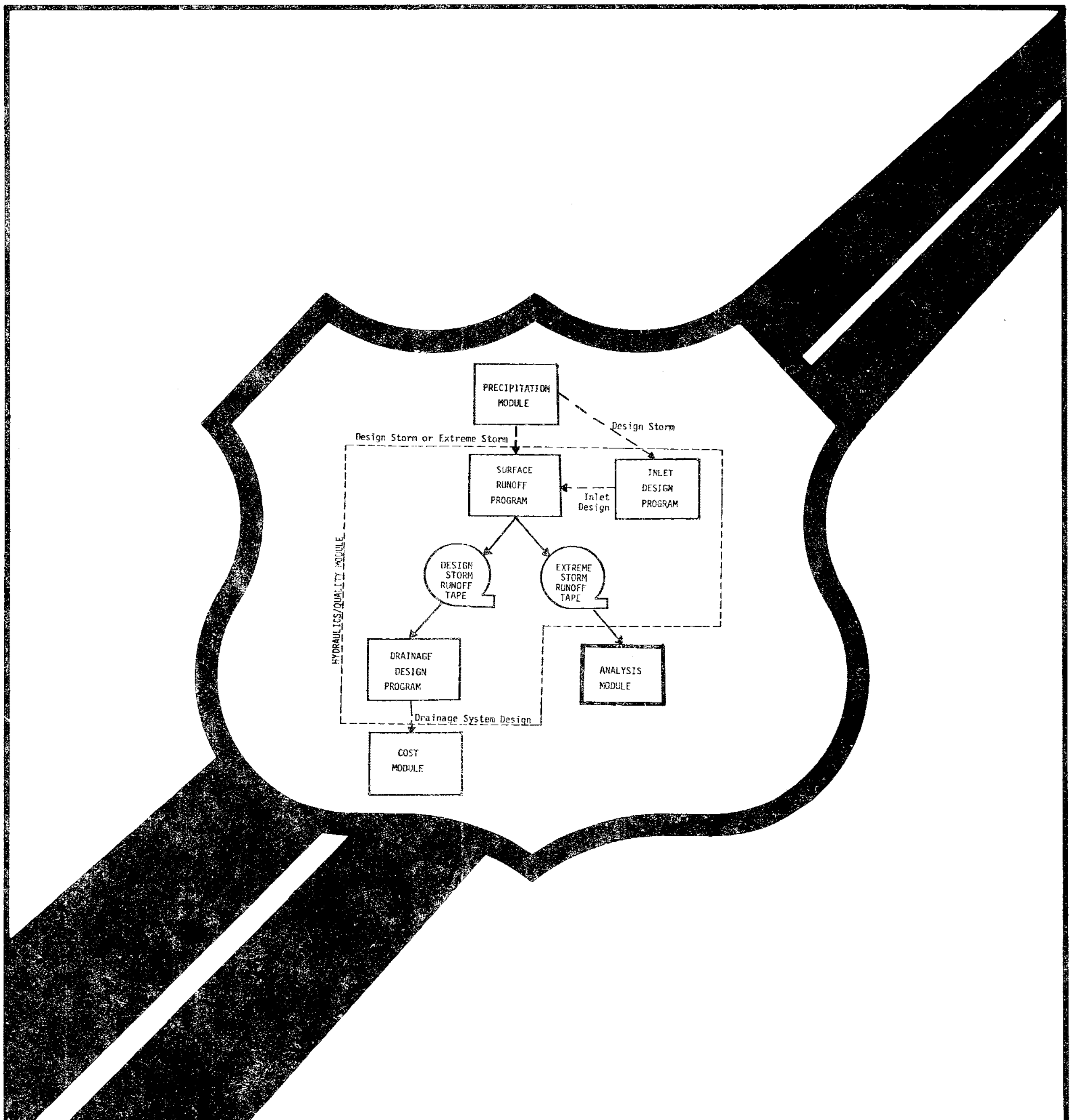

FOREWORD

This report documents the development and presents the user's manual for the Analysis Module of this computer model. Using inlet hydrographs computed from the Surface Runoff Program as input, this program simulates pumping station operation and/or the various flow control devices, and checks for backwater and surcharge of a system under excessive and extreme storm events.

Research and development in urban and rural highway storm drainage is included in the Federally Coordinated Program of Highway Research, Development, and Technology Project 5H "Highway Drainage and Flood Protection." Dr. Roy E. Trent is the Project Manager and Dr. D. C. Woo is the Contracting Officer's Technical Representative for this study.

This report is being distributed on request only due to the specialized nature of the contents.

Richard E. Hay, Director
Office of Engineering
and Highway Operations
Research and Development
Federal Highway Administration

NOTICE

NOTICE

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16. Abstract

A package of six user-oriented computer programs has been developed and tested for the analysis and design of urban highway drainage systems and related nonpoint source pollution problems. These programs are organized into four related but independent Modules.

This report consists of the documentation and user's manual for the Analysis Module. This program simulates unsteady gradually-varied flow in the drainage system, using inlet hydrographs from the Surface Runoff Program as input. Special conditions that can be simulated include surcharge, backwater, and pumping station operation.

This report is the seventh in a series. The others in the series are:

Vol. No.	FHWA No.	Short Title
-	83/040	Executive Summary
1	83/041	Model Development and Test Applications
2	83/042	Precipitation Module
3	83/043	Inlet Design Program
4	83/044	Surface Runoff Program
5	83/045	Drainage Design Program
7	83/047	Cost Estimation Module

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CHAPTER 1

OVERVIEW OF THE URBAN HIGHWAY STORM DRAINAGE MODEL

The Urban Highway Storm Drainage Model consists of four modules in six computer programs, developed for the Federal Highway Administration, U.S. Department of Transportation by the Water Resources Division of Camp Dresser & McKee Inc. The basic purpose of this package of programs is to provide the engineer with computational tools to assist in the analysis and design of highway drainage systems. Due to the nature of the problem, this model is not intended to fully automate the design process. Each module or program can be used separately to suit the designer's purpose.

The programs of the model are organized into four related but independent modules, as follows:

- Precipitation Module
- Hydraulics/Quality Module
  - Surface Runoff Program
  - Inlet Design Program
  - Drainage Design Program
- Analysis Module
- Cost Module

The Precipitation Module can perform a variety of statistical analyses on long-term hourly precipitation data and generate design storm hyetographs. The Hydraulics/Quality Module is the basic design tool in the package. This module simulates time-varying runoff quantity and quality, locates stormwater inlets and sizes the conduits of the major drainage system. The Analysis Module simulates unsteady gradually-varied flow in the drainage system and can be used to analyze complex hydraulic conditions, such as surcharge and backwater, that may be encountered during extreme storm events. The Cost Module can be used to estimate construction, operation and maintenance, and total annual costs associated with the drainage system.

The interrelationships among the computer programs are illustrated by Figure 1-1. As can be seen from this figure, there are a variety of ways in which these programs can be used independently or in conjunction with each other. This flexibility should allow the engineer to apply one or more of these programs to a wide variety of common stormwater-related problems. The major features of each of the programs are summarized in Tables 1-1 through 1-4.

This chapter is intended only to give the reader a broad overview of the Urban Highway Storm Drainage Model. To gain an understanding of the potential applications, the capabilities and the limitations of a particular program in the package, the engineer will need to study the appropriate User's Manual and Documentation Report.

This report is the User's Manual and Documentation Report for the Analysis Module. Chapter 2 of the report is an introduction to this program, describing the general approach used in the program and how the program fits into the drainage design process. The technical approach employed in the program is presented in some detail in Chapter 3. Finally, Chapter 4 is a complete user's manual for the program including input requirements, a Fortran listing of the program, and an example problem.

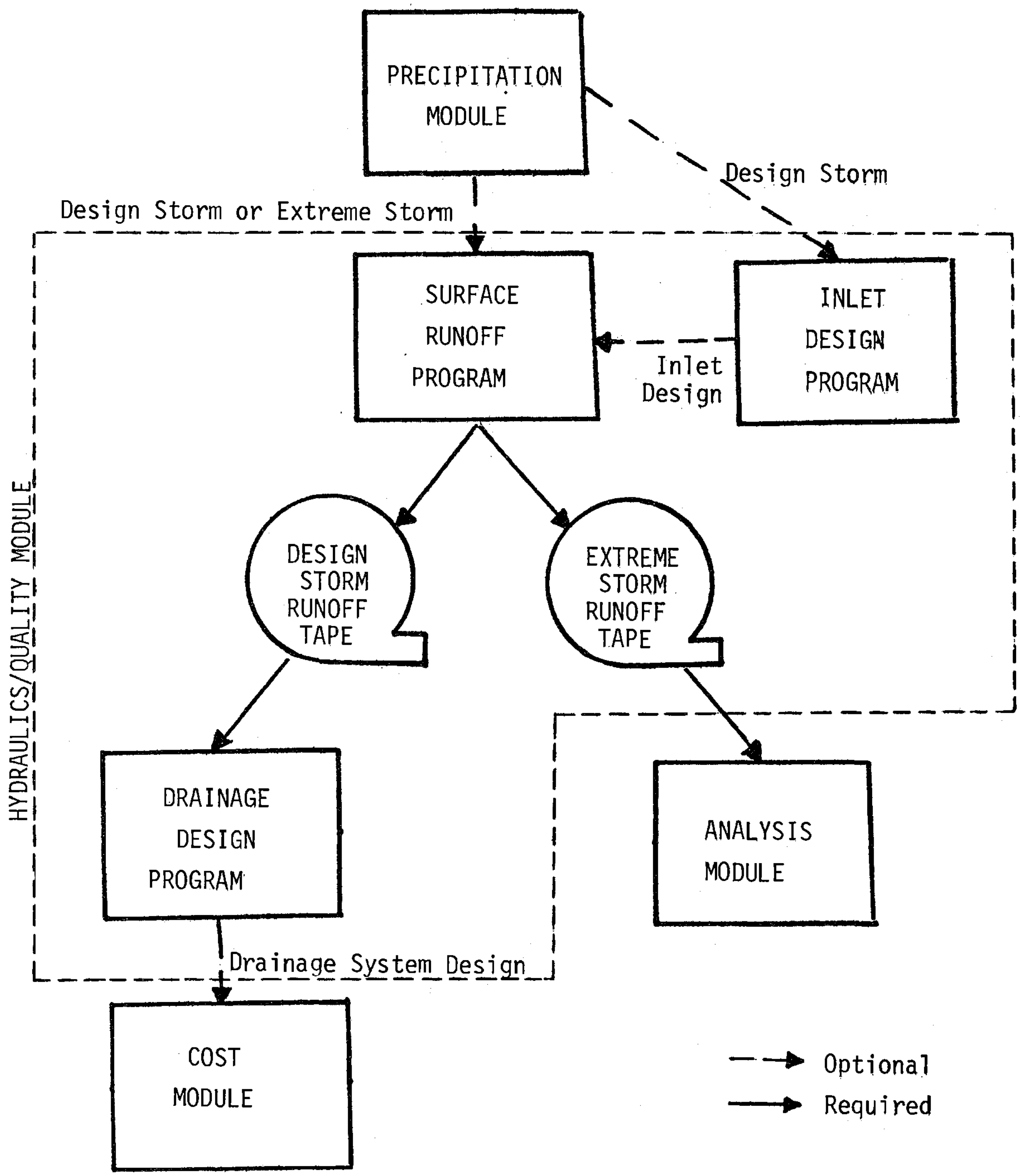


FIGURE 1-1 Urban Highway Storm Drainage Model

TABLE 1-1

MAJOR FEATURES OF THE PRECIPITATION MODULE

- Derivation of Hyetographs of Selected Return Frequency, Duration, and Skew
- Statistical Analysis of Hourly Rainfall Records to Generate Intensity-Duration-Frequency Curves
- Frequency of Occurrence Analysis of Hourly Rainfall Records for Peak Rainfall Intensity, Storm Duration, and Dry Period Duration
- Statistical Analysis of Hourly Rainfall Records for Storm Skew

TABLE 1-2

MAJOR FEATURES OF HYDRAULICS/QUALITY MODULE PROGRAMS

INLET DESIGN PROGRAM (INLET)

- Simulation of Time-Varying Runoff and Gutter/Channel Flow
- Spacing of Fixed-Size Inlets in Gutters or Channels
- Prespecification of Inlet Locations if Required
- Simulation of Six Basic Inlet Types

SURFACE RUNOFF PROGRAM (SRO)

- Simulation of Time-Varying Runoff and Gutter/Channel Flow
- Simulation of Accumulation and Washoff of Suspended Solids and Associated Pollutants
- Simulation of All Inlet Types Considered in Inlet Design Program
- Simulation of Four Types of Gutters/Channels
- Generation of Runoff Tape (Inlet Hydrographs and Pollutographs)

DRAINAGE DESIGN PROGRAM (DRAIN)

- Standard Pipe Sizing
- Sizing of Trapezoidal Open Channels
- Routing of Pollutants Through Drainage System
- Simulation of Treatment at Outfalls (Suspended Solids Removal)

TABLE 1-3

MAJOR FEATURES OF THE ANALYSIS MODULE

- Analysis of Extreme Storm Event Hydraulic Conditions in the Major Drainage System Such as Surcharge, Back-water, and Surface Flooding

- Simulation of Unsteady Gradually-Varied Flow in the Major Drainage System

- Simulation of Channels and Pipes of Five Different Cross-Sections

- Simulation of Pumping Station Operation

TABLE 1-4

MAJOR FEATURES OF THE COST ESTIMATION MODULE

- Calculation of Capital Costs for Construction of Major Drainage Systems

- Calculation of Operation and Maintenance Costs and Total Annual Costs for Major Drainage Systems

- Estimation of Excavation and Backfill Volumes Associated with Construction of Major Drainage Systems

CHAPTER 2
INTRODUCTION TO THE ANALYSIS MODULE

BACKGROUND

The Analysis Module (ANALYSIS) is a hydraulic flow routing model for open channel and/or closed conduit systems. ANALYSIS receives hydrograph input at specific nodal locations by tape transfer from the Surface Runoff Program and/or by input. The model performs dynamic routing of stormwater flows through the major storm drainage system to the points of outfall to the receiving water system. The program will simulate branched or looped networks, backwater due to tidal or nontidal conditions, free-surface flow, pressure flow or surcharge, flow reversals, flow transfer by weirs, orifices and pumping facilities, and storage at on or off-line facilities. Types of channels that can be simulated include circular, rectangular, horseshoe, egge, and baskethandle pipes, plus trapezoidal channels. Simulation output takes the form of water surface elevations and discharge at selected system locations.

This program was developed originally for the City of San Francisco in 1973 (1,2). At that time it was called the San Francisco Transport Model and (more properly) the WRE Transport Model. In 1974, EPA acquired this model and incorporated it into the SWMM package, calling it the Extended Transport Model -- EXTRAN -- to distinguish it from the TRANSPORT Module developed by the University of Florida as part of the original SWMM package. Since that time, the model has been refined, particularly in the way the flow routing is performed under surcharge conditions. Also, much experience has been gained in the use and misuse of the model. ANALYSIS is a special adaptation of EXTRAN designed for use in highway drainage problems and incorporated into the Urban Highway Storm Drainage Model.

GENERAL APPROACH

The highway storm drainage system consists of a surface runoff conveyance system and a major drainage system. Figure 2-1 shows a section of typical urban highway including the major components of the drainage system. As can be seen in the figure, runoff from the highway surface and the surface of the right-of-way is collected in roadside gutters and channels. The runoff is routed to a series of inlets, located to remove runoff so as to prevent flooding of the highway surface. The runoff so collected is then routed through the underground conduit system, generally to a nearby stream or other body of water.

In the design or analysis of highway drainage systems, such as illustrated in Figure 2-1, the first basic step is the computation of surface runoff from a selected storm event. Often, this computation has consisted of no more than calculating a peak runoff flow for each drainage area using the rational formula. The Analysis Module works in conjunction with the Surface Runoff Program to provide a more sophisticated tool that can compute full runoff hydrographs, route these hydrographs through the surface drainage system, calculate inlet hydrographs, and route these inlet flows through the major drainage system. The Analysis Module should be used in those areas of the highway drainage system where backwater conditions, surcharge conditions, and special flow devices such as weirs, orifices, and pumps are deemed to be important.

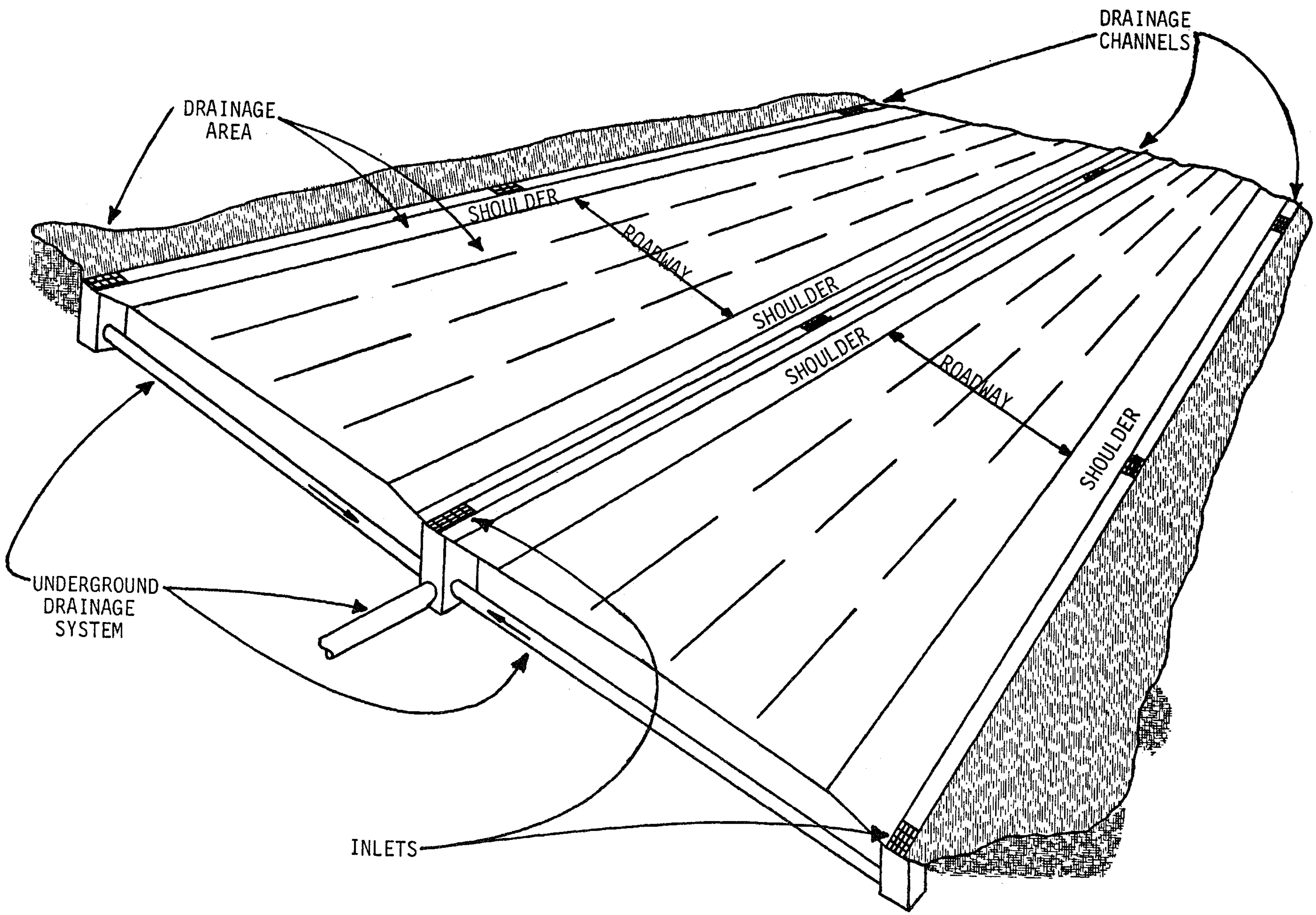


FIGURE 2-1. Typical Urban Highway Drainage System

CAPABILITIES AND LIMITATIONS

ANALYSIS is intended for application in systems where the assumption of steady flow, for purposes of computing backwater profiles, cannot be made. The program solves the full dynamic equation for gradually varied flow (Navier-Stokes equation) using an explicit solution technique to step forward in time. As a result, the solution time-step is governed by the wave celerity in the shorter channels or conduits in the system. Time-steps of 5-seconds to 60-seconds are typically used, which means that computer time is a significant consideration in use of the program.

The conceptual representation of the drainage system is based on the "link-node" concept which does not constrain the drainage system to a dendritic form. This permits a high degree of flexibility in type of problems that can be examined with ANALYSIS. These include parallel pipes, looped systems, lateral diversions such as weirs, orifices, pumps, and partial surcharge within the system.

Because of the versatility of ANALYSIS, there is a tendency for some users to apply the model to the entire drainage system being analyzed even though flow routing through most of the system could be performed with a simpler model such as the Drainage Design Program. The result is a very large system simulated at relatively small time-steps which produces great quantities of data that are difficult to digest. Where simpler programs are applicable (no backwater, surcharges, or bifurcations), substantial savings in data preparation and computer solution time can be realized using a simpler program.

ANALYSIS has limitations which, if not appreciated, can result in improperly specified systems and the erroneous computation of heads and flows. The significant limitations are these:

- Headloss at manholes, expansions, contractions, bends, etc., are not explicitly accounted for. These losses must be reflected in the value of the Manning n specified for the channels or conduits where the loss occurs.

- Changes in hydraulic head due to rapid expansions or contractions are neglected. At expansion, this assumption generally does not cause any problems but at contractions, an error in the head computation may be introduced.

- At a manhole where the inverts of the connecting pipes are different (e.g., a drop manhole) computational errors will occur during surcharge periods if the invert of the highest pipe lies above the crown of the lowest pipe. The severity of the error increases as the separation increases.

- Computational instabilities can occur at junctions with weirs if: 1) the junction is surcharged, and 2) the weir becomes submerged to the extent that the downstream head equals or exceeds the upstream head.

Methods for dealing with these problems are discussed in Chapter 3.

The Analysis Module is presently restricted to the following:

- There can be no more than 200 channels or pipes in the system;
- There can be no more than a total of 200 junctions in the system;
- There can be no more than 20 storage elements;
- There can be no more than 60 orifices;
- There can be no more than 60 weirs;
- There can be no more than 20 pumps;
- There can be no more than 25 outfalls.

Finally, a word of caution. ANALYSIS is a tool, like a calculator, that can assist engineers in the examination of the hydraulic response of a drainage system to inflow hydrographs. While the model is based on scientific truth, approximation in time and space are made in order to solve these problems. While we have tried to anticipate most prototype configurations, these approximations may not be appropriate in some system configurations or in unusual hydraulic situations. Therefore, persons using the computer program must be experienced hydraulicians. The computational results should never be taken for granted, but rather the computer output should be scanned for each simulation to look for suspicious results. The checking procedure should be analogous to that which would be followed in checking a backwater profile that a junior engineer had performed by hand computation. Remember that the major difference between the engineer and the computer is that the computer can't think!

COMPUTATIONAL REQUIREMENTS

The Analysis Module was originally programmed for the Univac 1108 in FORTRAN V. This version of the FORTRAN compiler is essentially compatible with the IBM FORTRAN LEVEL G compiler and the extended compiler used on CDC 6600 series equipment. The model was subsequently installed on IBM, CDC, DEC 20, and several other computers. The latest refinements to the model have been performed on the DEC 20 computer.

The core storage and peripheral equipment to operate this program are:

- High speed core: $\approx 126{,}000_8$ words
  $\approx 44{,}000_{10}$ words;
- Perpheral storage: 2 drum, disk or tape files;
- One card reader or input file device; and
- One line printer.

Execution times for ANALYSIS are roughly proportional to the number of system conduits and the number of time-steps in the simulation period. A summary of CDM's prior experience in running ANALYSIS on both CDC 6600 and Univac 1108 systems is presented graphically in Figure 2-2. Using the Univac 1108 operating data in Figure I as an example, it is estimated that the total computation time for a network of 100 pipes, using a 10-second time-step over a 1-hour simulation period, would be approximately 300 system-seconds. Run time for the Example problem in Chapter 4 (45 pipes, 2 hour simulation , 10 second time-step) was about 77 seconds on the DEC 20 computer. Note that the curves presented in Figure 2-2 become highly nonlinear for $\Delta t \leq 10$ seconds because of the increased frequency of internal tape transfers and output processing.

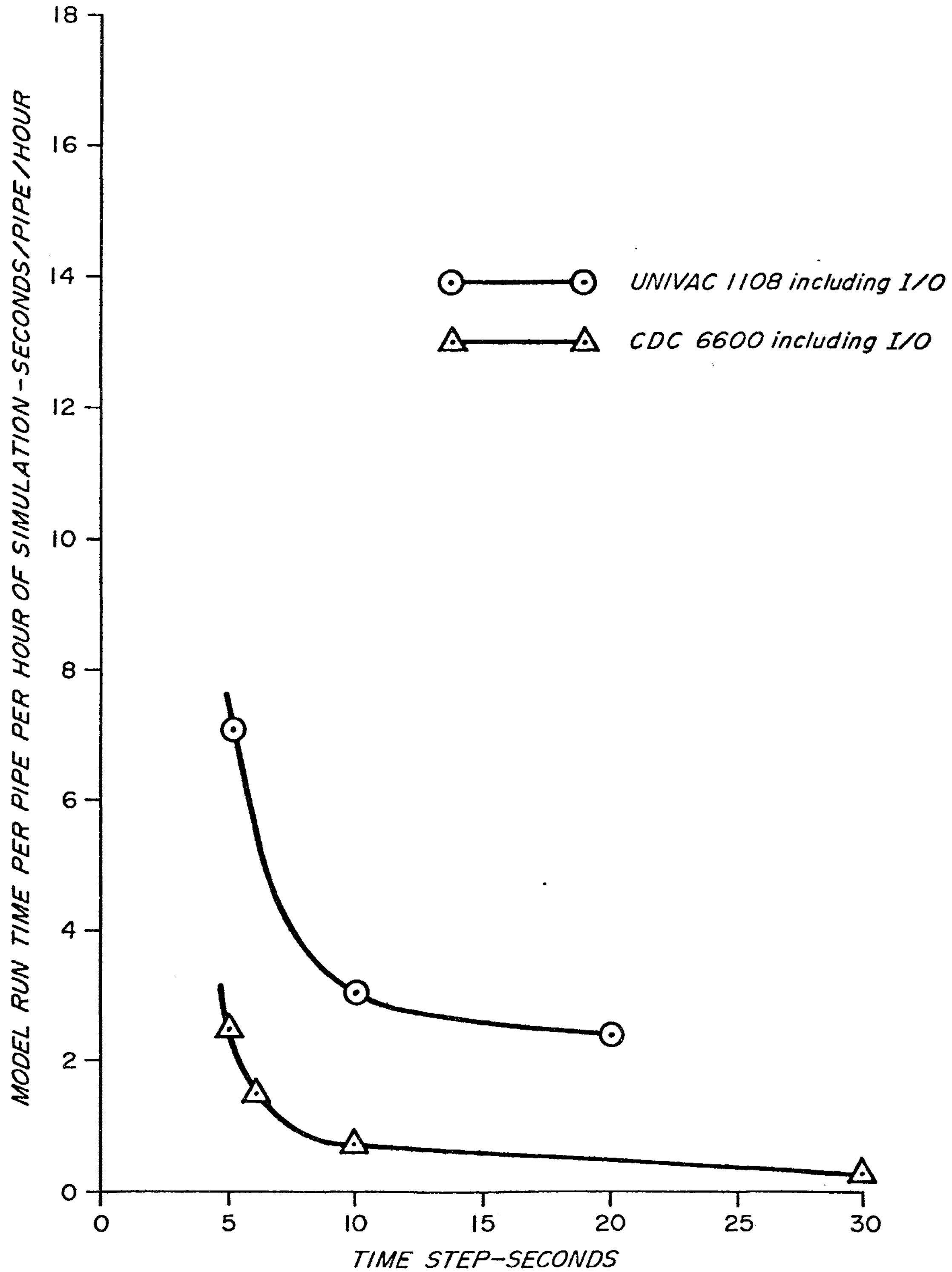


FIGURE 2-2. SUMMARY OF ANALYSIS RUN TIME
ON CDC AND UNIVAC SYSTEMS

CHAPTER 3
TECHNICAL APPROACH

GENERAL

A conceptual overview of ANALYSIS is shown in Figure 3-1. As shown here, the specific function of ANALYSIS is to route inlet hydrographs through the network of pipes, junctions, and flow diversion structures of the main sewer system to the receiving water outfalls. ANALYSIS must be used whenever it is important to represent severe backwater conditions and special flow devices such as weirs, orifices, pumps, storage basins, and tide gates. Normally these conditions occur in the lower reaches of the drainage system when pipe diameters exceed roughly 24 inches. The Surface Runoff Program and the Drainage Design Program, on the other hand, are well suited for the simulation of overland flow, gutter/channel flow and pipe flow in the upper regions of the system where the kinematic assumptions of uniform flow hold.

As shown in Figure 3-1, ANALYSIS simulates the following elements: pipes; manholes (pipe junctions); weirs; orifices; pumps; storage basins; and outfall structures. These elements and their associated properties are summarized in Tables 3-1 and 3-2. Output from ANALYSIS takes the form of: 1) discharge hydrographs and velocities in selected conduits in printed and plotted form; and 2) flow depths and water surface elevations at selected junctions in printed and plotted form.

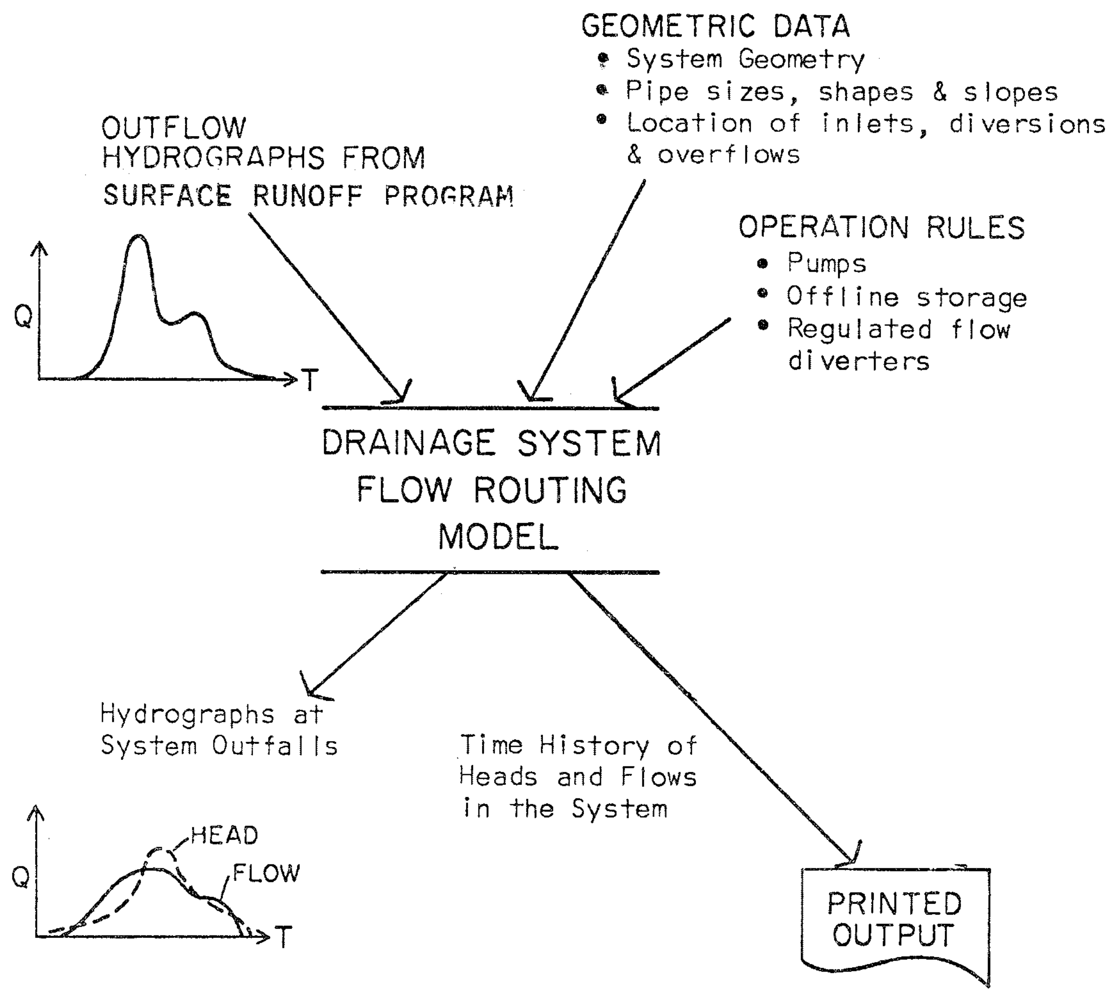


FIGURE 3-1
SCHEMATIC ILLUSTRATION OF ANALYSIS

TABLE 3-1

CLASSES OF ELEMENTS INCLUDED IN THE ANALYSIS MODULE

Element Class	Types
Conduits or Links	Rectangular Circular Horseshoe Baskethandle Eggshape
Junctions or Nodes (Manholes)	----
Diversion Structures	Orifices Transverse weirs Sideflow weirs
Pump Stations	On-line or off-line pump station.
Storage Basins	On-line (enlarged pipes or tunnels)
Outfall Structures	Transverse weir with tide gate Transverse weir without tide gate Sideflow weir with tide gate Sideflow weir without tide gate Outfall with tide gate Free outfall without tide gate

TABLE 3-2

PROPERTIES OF NODES AND LINKS IN THE ANALYSIS MODULE

	Properties and Constraints
NODES	
Constraint	ΣQ = change in storage
Properties computed at each time step	Volume Surface area Head
Constant Properties	Invert, crown and ground elevations
LINKS	
Constraint	Qin = Qout
Properties computed at each time step	Cross-sectional area Hydraulic radius Surface width Discharge Velocity of flow
Constant Properties	Head loss coefficients Pipe shape, length, slope, roughness, invert and crown elevations

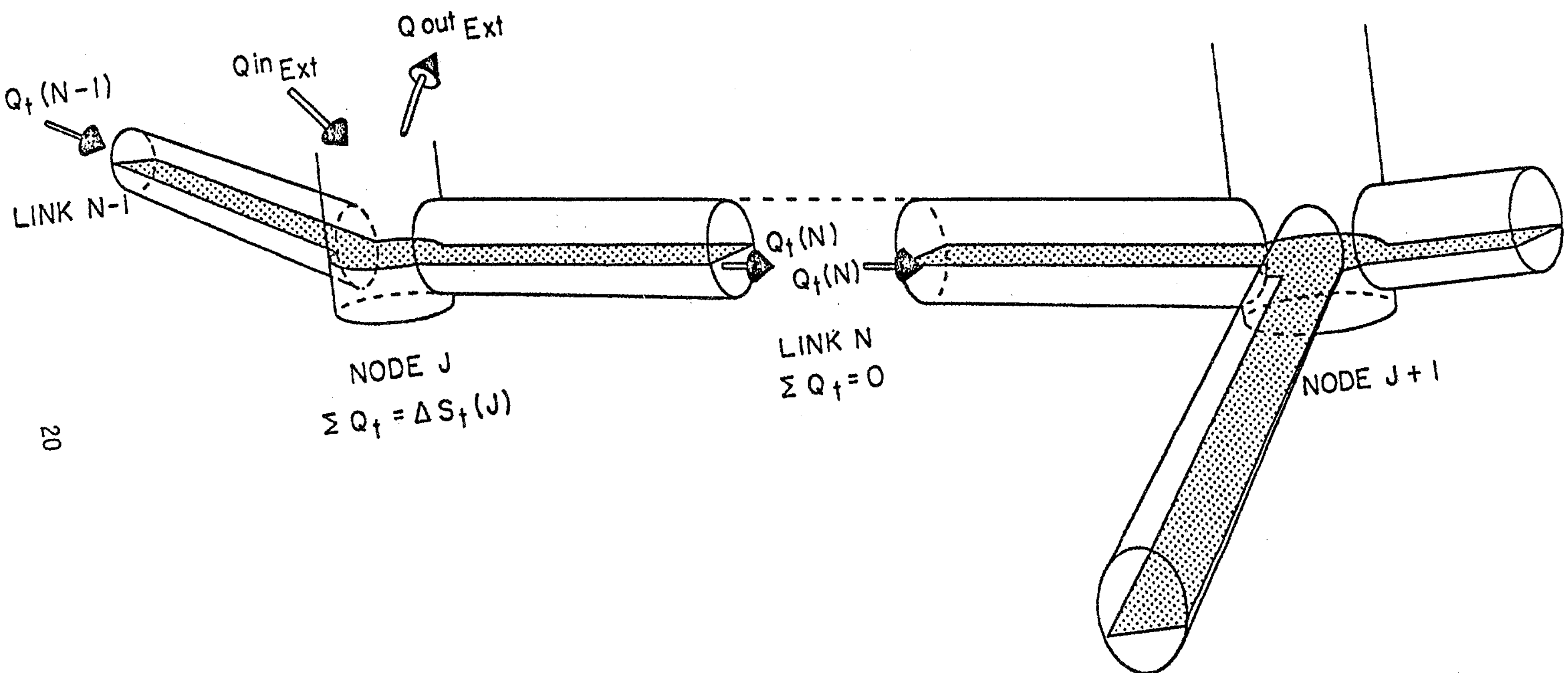
CONCEPTUAL REPRESENTATION OF THE DRAINAGE SYSTEM

ANALYSIS uses a link-node description of the storm sewer system which facilitiates the discrete representation of the physical prototype and the mathematical solution of the gradually-varied unsteady flow equations which form the mathematical basis of the model.

As shown in Figure 3-2, the conduit system is idealized as a series of links or pipes which are connected at nodes or junctions. Links and nodes have well defined properties which, taken together, permit representation of the entire pipe network. Moreover, the link-node concept is very useful in representing flow control devices. The specific properties of links and nodes have been summarized in Table 3-2.

Links transmit flow from node to node. Properties associated with the links are roughness, length, cross-sectional area, hydraulic radius, and surface width. The last three properties are functions of the instantaneous depth of flow. The primary dependent variable in the links is the discharge, Q. It is assumed that Q is constant in the link, while velocity and the cross-sectional area of flow, or depth, are variable in the link. In the early development of the Analysis Module, a constant velocity approach was used, but this was found later to produce highly unstable solutions.

Nodes are the storage elements of the system and correspond to manholes or pipe junctions in the physical system. The variables associated with a node are volume, head, and surface area. The primary dependent variable is the head, H, which is assumed to be changing in time but constant throughout any one node. Inflows, such as inlet hydrographs, and outflow, such as weir diversions, take place at the nodes of the idealized storm sewer system. The volume of the node at any time is equivalent to the water volume in the half-pipe lengths connected to any one node. The change in nodal volume during a given time-step, Δt, forms the basis of head and discharge calculations as discussed below.



Q = flow

S = storage

FIGURE B-2
CONCEPTUAL REPRESENTATION OF THE TRANSPORT SYSTEM

BASIC FLOW EQUATIONS

The basic differential equations for the sewer flow problem come from the gradually varied, unsteady flow equations for open channels, otherwise known as the Saint-Venant or shallow water equations. The equation for unsteady spatially varied discharge can be written:

$$\frac{\partial Q}{\partial t} = -gAS_f + 2V\frac{\partial A}{\partial t} + V^2 \frac{\partial A}{\partial x} - gA\frac{\partial H}{\partial x} \qquad (3\text{-}1)$$

where

Q = discharge through the conduit;
V = velocity in the conduit;
A = cross-sectional area of the flow;
H = hydraulic head; and
S_f = friction slope.

The friction slope is defined by Manning's equation, i.e.

$$S_f = \frac{k}{gAR^{4/3}} \; Q|V| \qquad (3\text{-}2)$$

where $k = g(n/1.49)^2$. Use of the absolute value sign on the velocity terms makes S_f a directional quantity and ensures that the frictional force always opposes the flow. Substituting in equation 3-1 and expressing the finite difference form gives:

$$Q_{t+\Delta t} = Q_t - \frac{k}{R^{4/3}} |V| \; Q_{t+\Delta t} + 2V\frac{\Delta A}{\Delta t} + V^2 \frac{A_2-A_1}{L} \Delta t - gA \frac{H_2-H_1}{L} \Delta t \qquad (3\text{-}3)$$

Solving equation 3-3 for $Q_{t+\Delta t}$ gives the final finite difference form of the dynamic flow equation as:

$$Q_{t+\Delta t} = \frac{1}{1 + \frac{k \cdot \Delta t}{\bar{R}^{4/3}} |\bar{V}|} \; Q_t + 2\bar{V}\,\Delta A + \bar{V}\,\frac{A_2-A_1}{L} \Delta t - g\bar{A}\,\frac{H_2-H_1}{L} \Delta t \qquad (3\text{-}4)$$

In equation 3-4, the values $\bar{V}$, $\bar{R}$, and $\bar{A}$ are weighted averages of the conduit end values at time t.

The basic unknowns in equation 3-4 are $Q_{t+\Delta t}$, H_2 and H_1. The variables $\overline{V}$, $\overline{R}$, and $\overline{A}$ can all be related to Q and H. We therefore require another equation relating Q and H. This can be obtained by writing the continuity equation at a node.

$$\frac{\partial H}{\partial t}_t = \frac{\Sigma Q_t}{A_{s_t}} \qquad (3\text{-}5)$$

or in finite difference form

$$H_{t+\Delta t} = H_t + \frac{\Sigma Q_t \, \Delta t}{A_{s_t}} \qquad (3\text{-}6)$$

SOLUTION OF FLOW EQUATIONS BY MODIFIED EULER METHOD

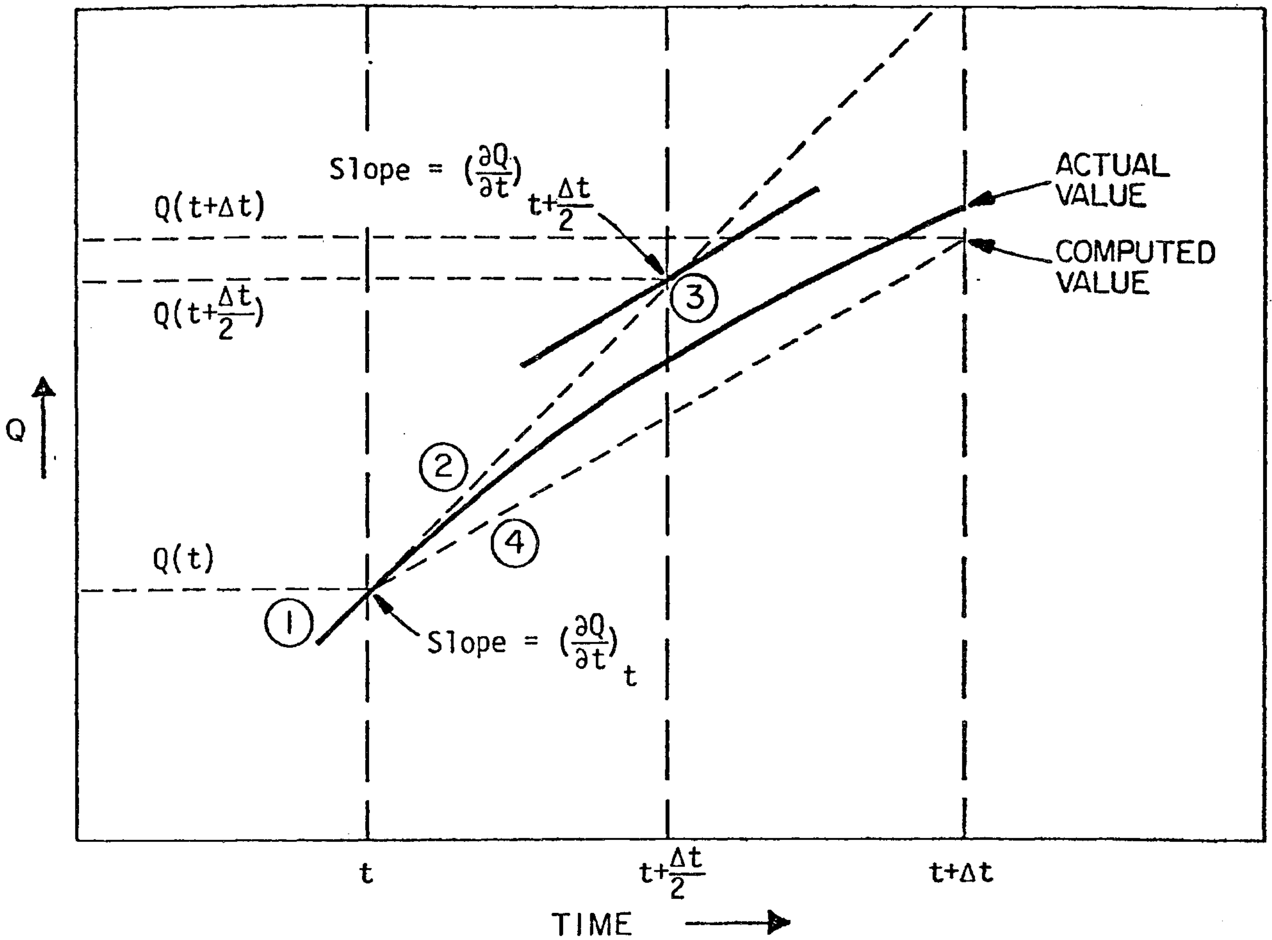
Equations 3-4 and 3-6 can now be solved sequentially to determine discharge in each link and head at each node over a time step Δt. The numerical integration of equations 3-4 and 3-6 is accomplished by a modified Euler method. The results are accurate and, when certain constraints are followed, stable. Figure 3-3 shows how the process would work if only the discharge equation were involved. The first three operations determine the slope $\partial Q/\partial t$ at the "half-step". This is used in operation (4) to project the "full-step" value of discharge. In other words, it is assumed that the slope at time $t + \frac{\Delta t}{2}$ is the mean slope during the interval. The method is extended easily to more than one equation, although graphic representation is then very difficult. The corresponding half-step and full-step calculations of head are shown below:

<u>Half-step at node j: Time $t + \frac{\Delta t}{2}$</u>

$$H_j(t + \tfrac{\Delta t}{2}) = H_j(t) + \tfrac{1}{2} \sum_{\substack{\text{conduits}\\ \text{surface runoff}}} [Q(t) + Q(t + \tfrac{\Delta t}{2})] + \sum_{\substack{\text{diversions}\\ \text{pumps}\\ \text{outfalls}}} Q(t + \tfrac{\Delta t}{2}) \;\; /AS_j(t) \qquad (3\text{-}7)$$

<u>Full-step at node j: Time $t + \Delta t$</u>

$$H_j(t + \Delta t) = H_j(t) + \tfrac{1}{2} \sum_{\substack{\text{conduits}\\ \text{surface runoff}}} [Q(t) + Q(t + \Delta t)] + \sum_{\substack{\text{diversions}\\ \text{pumps}\\ \text{outfalls}}} Q(t + \Delta t) \;\; /AS_j(t) \qquad (3\text{-}8)$$



(1) Compute $(\frac{\partial Q}{\partial t})_t$ from properties of system at time t

(2) Project $Q(t+\frac{\Delta t}{2})$ as $Q(t+\frac{\Delta t}{2}) = Q(t) + (\frac{\partial Q}{\partial t})_t \frac{\Delta t}{2}$

(3) a. Compute system properties at $t+\frac{\Delta t}{2}$

b. Form $(\frac{\partial Q}{\partial t})_{t+\frac{\Delta t}{2}}$ from properties of system at time $t+\frac{\Delta t}{2}$

(4) Project $Q(t+\Delta t)$ as $Q(t+\Delta t) = Q(t) + (\frac{\partial Q}{\partial t})_{t+\frac{\Delta t}{2}} \Delta t$

FIGURE 3-3

MODIFIED EULER SOLUTION METHOD FOR DISCHARGE BASED ON HALF-STEP, FULL-STEP PROJECTION

Note that the half-step computation of head uses the half-step computation of discharge in all connecting conduits. Similarly, the full-step head computation requires the full-step discharge at time $t + \Delta t$ for all connecting pipes. In addition, the inflows to the diversions from each node by weirs, orifices, and pumps must be computed at each half and full-step. The total sequence of discharge computations in the links and head computations in the nodes can be summarized as:

1. Compute half-step discharge at $t + \frac{\Delta t}{2}$ in all links based on preceding full-step values of head at connecting junctions.
2. Compute half-step flow transfers by weirs, orifices, and pumps at time $t + \frac{\Delta t}{2}$ based on preceding full-step values of head at transfer junction.
3. Compute half-step head at all nodes at time $t + \frac{\Delta t}{2}$ based on average of preceding full-step and current half-step discharges in all connecting conduits, plus flow transfers at the current half-step.
4. Compute full-step discharge in all links at time $t + \Delta t$ based on half-step heads at all connecting nodes.
5. Compute full-step flow transfers between nodes at time $t + \Delta t$ based on current half-step heads at all weir, orifice, and pump nodes.
6. Compute full-step head at time $t + \Delta t$ for all nodes based on average of preceding full-step and current full-step discharges, plus flow transfers at the current full-step.

NUMERICAL STABILITY

The modified Euler method yields a completely explicit solution in which the motion equation is applied to discharge in each link and the continuity equation to head at each node entirely without implicit coupling.

It is well known that explicit methods involve fairly simple arithmetic and require little storage space compared to implicit methods. However, they are generally less stable and often require very short time-steps. From a practical standpoint, experience with the Analysis Module has indicated that the program is stable numerically when the following inequalities are met, for conduits and nodes, respectively:

$$\Delta t \leq \frac{L}{\sqrt{gD}} \qquad (3\text{-}9)$$

where L is the pipe length in feet, g is gravity (32.2 ft/sec^2), D is the pipe depth and Δt the time-step in seconds; and

$$\Delta t \leq \frac{C' \, A_s \Delta H_{max}}{\Sigma Q} \qquad (3\text{-}10)$$

where C' is a dimensionless constant determined by experience to be approximately 0.10, ΔH_{max} is the maximum water-surface rise in time-step Δt, A_s is the corresponding surface area of the node, and ΣQ is the net inflow to the junction.

Examination of inequalities 3-9 and 3-10 reveals that the maximum allowable time, Δt, will be determined by the shortest, smallest pipe having high inflows. Based on past experience with ANALYSIS, a time-step of 10 seconds is nearly always sufficiently small to produce outflow hydrographs and state-time traces which are free from spurious oscillation and also satisfy mass continuity under non-flooding conditions. In most applications, 15 to 30 second time-steps are adequate; occasionally time-steps up to 60 seconds can be used.

Equivalent Pipes

An equivalent pipe is the computational substitution of an actual element of the drainage system by an imaginary conduit which is hydraulically identical to the element it replaces. Usually an equivalent pipe is used when it is suspected that a numerical instability will be caused by the element of the drainage system being replaced in the computation. Short conduits and weirs are known at times to cause stability problems and thus occasionally need to be replaced by an equivalent pipe. (Orifices are automatically converted to equivalent pipes by the program; see the description below.)

The equivalent pipe substitution used by ANALYSIS involves the following steps. First the flow equation for the element in question is set equal to the flow equation for an "equivalent pipe". This in effect says that the head losses in the element and its equivalent pipe are the same. The length of the equivalent pipe is computed using the numerical stability equation 3-9. Then, after making any additional assumptions which may be required about the equivalent pipe's dimensions, a Manning's n is computed based on the equal head loss requirement. In the case of orifices, this conversion occurs internally in ANALYSIS, but in those cases where short pipes and weirs are found to cause instabilities, the user must make the necessary conversion and revise the input data set. The user's guide found in Chapter 4 of this report outlines the steps needed to make these conversions.

SPECIAL PIPE FLOW CONSIDERATIONS

The solution technique discussed in the preceding paragraphs cannot be applied without modification to every conduit for the following reasons. First, the invert elevations of pipes which join at a node may be different since sewers are built frequently with invert discontinuities. Second, critical depth may occur in the conduit and thereby restrict the discharge. Third, normal depth may control. Finally, the pipe may be dry. In all of these cases, or combinations thereof, the flow must be computed by special techniques. Figure 3-4 shows each of the possibilities and describes the way in which surface area is assigned to the nodes. The options are:

1. Normal case. Flow computed from motion equation. Half of surface area assigned to each node.
2. Critical depth downstream. Use lesser of critical or normal depth downstream. Assign all surface area to upstream node.

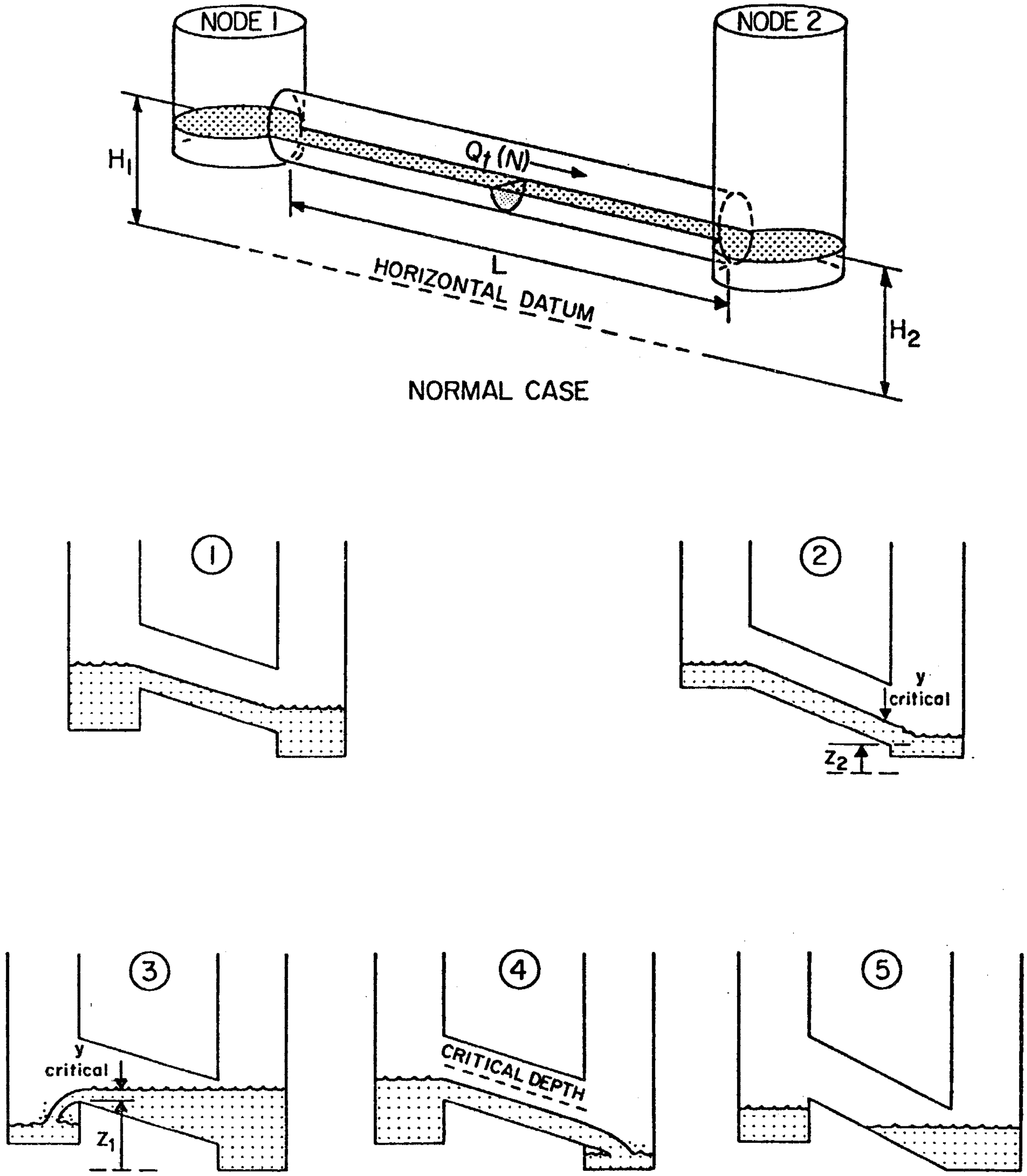


FIGURE 3-4

SPECIAL HYDRAULIC CASES IN TRANSPORT FLOW CALCULATIONS

3. Critical depth upstream. Use critical depth. Assign all surface area to downstream node.
4. Flow computed exceeds normal flow at a supercritical depth. Set flow to normal value. Assign surface area in usual manner as in (1).
5. Dry pipe. Set flow to zero. If any surface area exists, assign to downstream node.

Once these depth and surface area corrections are applied, the computations of head and discharge can proceed in the normal way for the current time-step. Note that any of these special situations may begin and end at various times and places during simulation. ANALYSIS detects these automatically.

HEAD COMPUTATION DURING SURCHARGE AND FLOODING

Another hydraulic situation which requires special treatment is the occurrence of surcharge and flooding. Surcharge occurs when all pipes entering a node are full or when the water surface at the node lies between the crown of the highest entering pipe and the ground surface.

Flooding is a special case of surcharge which takes place when the hydraulic grade line breaks the ground surface and water is lost from the storm sewer node to the overlying surface system. While it would be possible to track the water lost to flooding by surface routing, this is not done in the present version of ANALYSIS.

During surcharge, the head calculation in equations 3-7 and 3-8 is no longer possible because the surface area of the surcharged node is zero. Thus, the continuity equation for node j at time t is

$$\Sigma Q\,(t) = 0 \qquad (3\text{-}11)$$

where $\Sigma Q\,(t)$ is all inflows to and outflows from the node from surface runoff conduits, diversion structures, pump, and outfalls.

Since the flow and continuity are not solved simultaneously in the model, the flows computed in the links connected to node j will not satisfy equation 3-11. However, computing $\frac{\partial Q}{\partial H_j}$ for each link connected to node j, a head adjustment can be computed such that the continuity equation is satisfied. Rewriting equation 3-11 in terms of the adjusted head gives:

$$\Sigma\left(Q(t) + \frac{\partial Q(t)}{\partial H_j}\,\Delta H_j(t)\right) = 0 \qquad (3\text{-}12)$$

which can be solved for ΔH_j as

$$\Delta H_j(t) = -\Sigma Q(t)/\Sigma\,\frac{\partial Q(t)}{\partial H_j} \qquad (3\text{-}13)$$

This adjustment is made by half-steps during surcharge so that the half-step correction is given as:

$$H_j\left(t + \frac{\Delta t}{2}\right) = H_j(t) + k\Delta H_j\left(t + \frac{\Delta t}{2}\right) \qquad (3\text{-}14)$$

where $\Delta H_j(t + \frac{\Delta t}{2})$ is given by equation 3-13, while the full-step head is computed as:

$$H_j(t + \Delta t) = H_j(t + \frac{\Delta t}{2}) + k\ \Delta H_j(t) \tag{3-15}$$

where $\Delta H_j(t)$ is described by equation 3-13. The value of the constant k theoretically should be 1.0. However, it has been found that equations 3-14 and 3-15 tend to overcorrect the head; therefore, a value of 0.5 is used for k which gives much better results.

Conduits

For conduits connected to a node being surcharged, $\partial Q/\partial H$ is computed as follows:

$$\frac{\partial Q(t)}{\partial H_j} = \frac{32.2}{1-K(t)}\ \Delta t\ (\frac{A(t)}{L}) \tag{3-16}$$

where

$K(t) = -\Delta t\ \frac{32.2\ n^2}{2.208\ R^{4/3}}\ |v(t)|$;

Δt = time interval;

$A(t)$ = flow cross sectional area in the conduit;

L = conduit length;

n = Manning n;

R = hydraulic radius for the full conduit, and

$v(t)$ = velocity in the conduit.

System Inflows

For system inflows during surcharge, $\partial Q/\partial H$ is computed as follows:

$$\frac{\partial Q(t)}{\partial H_j} = 0 \tag{3-17}$$

Orifice, Weir, Pump, or Outfall Diversions

Orifices are converted to equivalent pipes by the program (see below); therefore, equation 3-16 is used to compute $\partial Q/\partial H$. For weirs, $\partial Q/\partial H$ in the weir link is taken as zero, i.e., the effect of the flow changes over the weir due to a change in head is ignored in adjusting the head at surcharged weir junctions. (The weir flow, of course, is computed in the next time-step on the basis of the adjusted head.) As a result, the solution may go unstable under surcharge conditions. If this occurs, the weir should be changed to an equivalent pipe as described in Chapter 4, under Card Group 11.

$\partial Q/\partial H$ for pump junctions is also taken as zero. For off-line pumps (with a wet well), this is a valid statement since Q_{pump} is determined by the volume in the wet well, not the head at the junction. For in-line pumps, where the pump rate is determined by the water depth at the junction, a problem could occur if the pumping rate is not set at its maximum value at a depth less than surcharge depth at the junction. This situation should be avoided if possible because it could cause the solution to go unstable if a large step increase or decrease in pumping rate occurs while the pump junction is surcharged.

For an outfall pipe, the head adjustment at the outfall is treated as any other junction. Outfall weir junctions are treated the same as internal weir junctions ($\partial Q/\partial H$ for the weir link is taken as zero). Thus, unstable solutions can occur at these junctions also under surcharge conditions. Converting these weirs to equivalent pipes will eliminate the stability problem.

Because the head adjustments computed in equations 3-14 and 3-15 are approximations, the computed head has a tendency to "bounce" up and down when the conduit first surcharges. This bouncing can cause the solution to go unstable in some cases, therefore, a transition function is used to smooth the changeover from head computation by equations 3-7 and 3-8 to equations 3-14 and 3-15. The transition function used is:

$$\Delta H_j(t) = \frac{\Sigma Q(t)}{DENOM} \qquad (3\text{-}18)$$

where

DEMON is given by

$$\text{DENOM} = \frac{\partial Q(t)}{\partial H_j} + \left(AS_j(t) - \frac{\partial Q(t)}{\partial H_j}\right) \exp\left(- \frac{15(y_j - D_j)}{D_j}\right) \qquad (3\text{-}19)$$

and

AS = the nodal surface area at 0.96 full depth;

D_j = pipe diameter; and

y_j = water depth.

The exponential junction causes equation 3-19 to converge within 2 percent of equation 3-13 by the time the water depth is 1.25 times the full flow depth.

Finally, it is noted that when flooding of the node above the ground surface is detected, ANALYSIS automatically resets the water surface at the ground elevation of the node. Water rising above this level under flooding conditions is then lost from the system and does not return to ANALYSIS in the present version of the program.

FLOW CONTROL DEVICES

The link-node computations can be extended to include devices which divert a portion of the storm flow out of the main drainage system. In the Analysis Module, all diversions are assumed to take place at a node and are handled as internodal transfers. The special flow regulation devices treated by ANALYSIS include: storage devices; orifices; weirs (both sideflow and transverse); pumps; and outfalls. Each of these is discussed in the paragraphs below.

Storage Devices

Storage devices in-line or off-line act as flow control devices by providing for storage of excessive upstream flows thereby alternating and lagging the wet weather flow hydrograph from the upstream area. The conceptual representations of a storage junction and a regular junction are illustrated in Figure 3-5. Note that the only difference is that added surface area in the amount of ASTORE is added to that of the connecting pipes. Note also that ZCROWN(J) is set at the top of storage "tank". When the hydraulic head at junction J exceeds ZCROWN(J), the junction goes into surcharge.

Orifices

Orifices may be found in certain storm sewer systems. Their purpose is usually to divert flow to another pipe, a pumping station or an off-line storage tank.

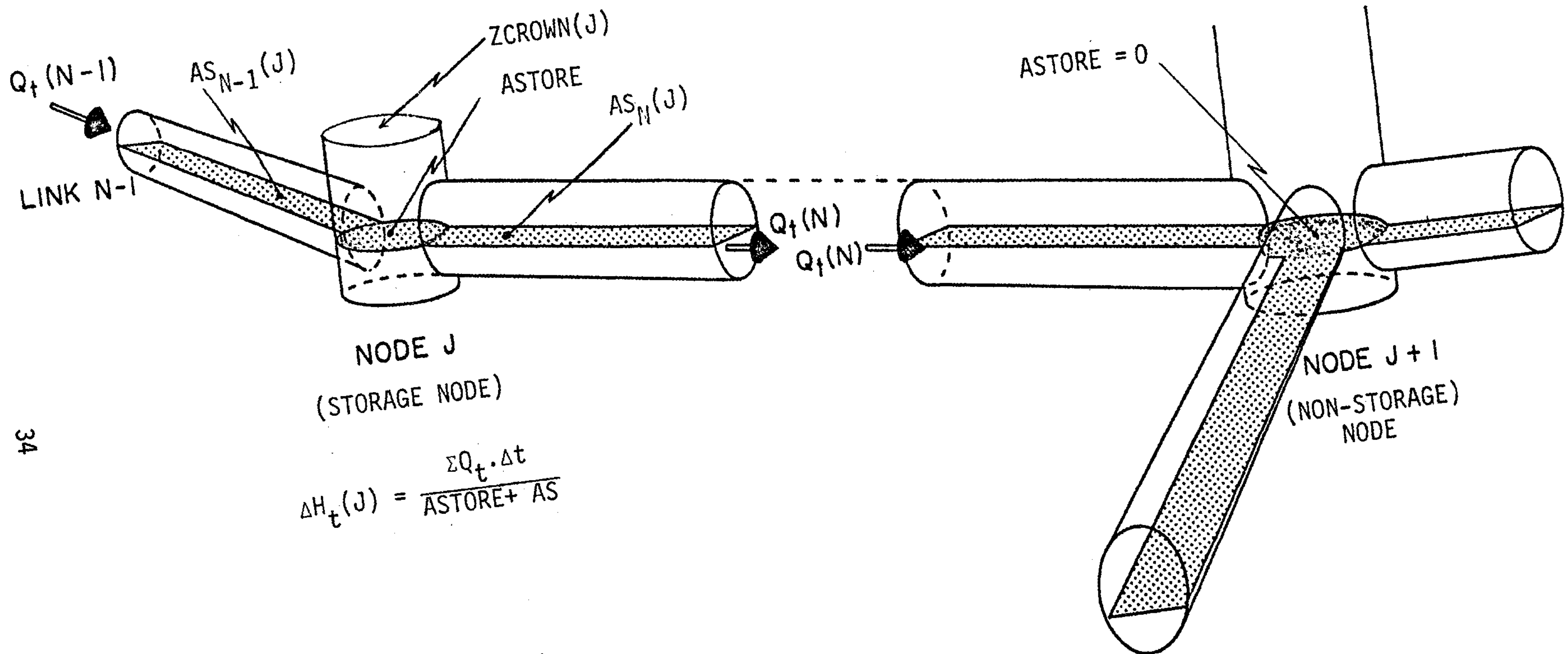
Figure 3-6 show two typical diversions: 1) a dropout or sump orifice; and 2) a side outlet orifice. ANALYSIS simulates both types of orifice by converting the orifice to an equivalent pipe. The conversion is made as follows. The standard orifice equation is:

$$Q_o = C_o A\sqrt{2gh} \qquad (3\text{-}20)$$

where C_o is the discharge coefficient (a function of the type of opening and the length of the orifice tube); A is the cross-sectional area of the orifice; g is gravity; and h is the hydraulic head on the orifice. Values of C_o and A are specified by the user. To convert the orifice to a pipe, the program equates the orifice discharge equation and the Manning pipe flow equation, i.e.,

$$\frac{1.49}{n} AR^{2/3} S^{1/2} = C_o A\sqrt{2gh} \qquad (3\text{-}21)$$

The orifice pipe is assumed to be nearly flat, the invert on the discharge side being set 0.01 feet lower than the invert on the inlet side. In addition, for a sump orifice, the pipe invert is set by the program 0.96D below the junction invert so that the orifice pipe is flowing full before any outflow from the junction occurs in any other pipe. For side outlet

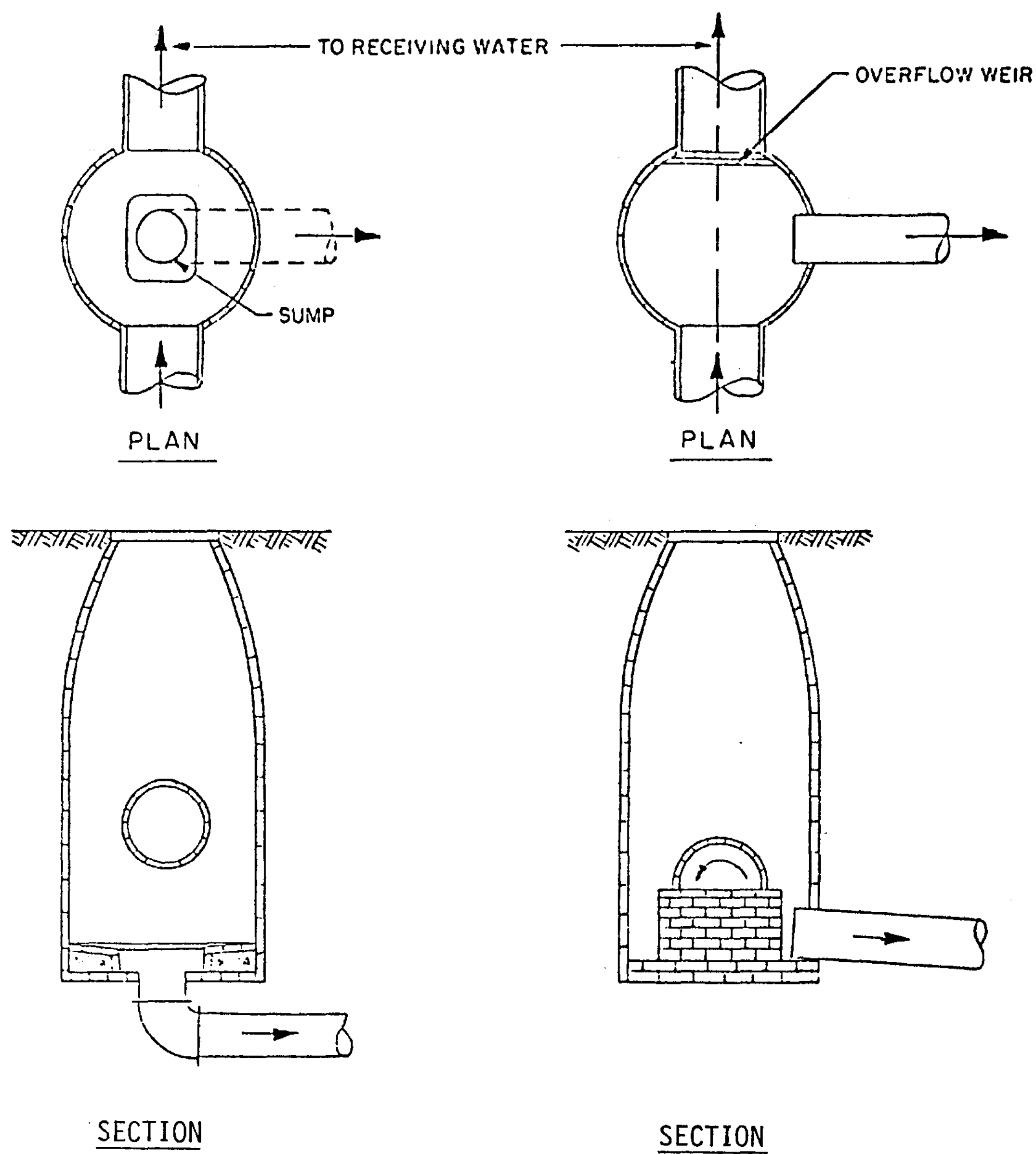


$$\Delta H_t(J) = \frac{\Sigma Q_t \cdot \Delta t}{ASTORE + AS}$$

Q = flow

S = storage

FIGURE 3-5
CONCEPTUAL REPRESENTATION OF A STORAGE JUNCTION



SUMP WITH HIGH OUTLET

WEIR WITH SIDE OUTLET ORIFICE

FIGURE 3-6

TYPICAL ORIFICE DIVERSIONS

orifices, the user specified the height of the orifice invert above the junction floor.

If we write S as H_s/L where L is the pipe length, H_s will be identically equal to h when the orifice is submerged. When it is not submerged, h will be the height of the water surface above the orifice centerline while H_s will be the distance of the water surface above critical depth (which will occur at the discharge end) for the pipe. For practical purposes, we can assume that H_s = h for this case also. Thus, letting s=h/L and substituting R = D/4 (where D is the orifice diameter) into equation 3-21 and simplifying, we have:

$$n = \frac{1.49}{\sqrt{2g\,C_o}} \frac{D^{2/3}}{L^{1/2}} \qquad (3\text{-}22)$$

The length of the equivalent pipe is computed as the maximum of 200 feet or

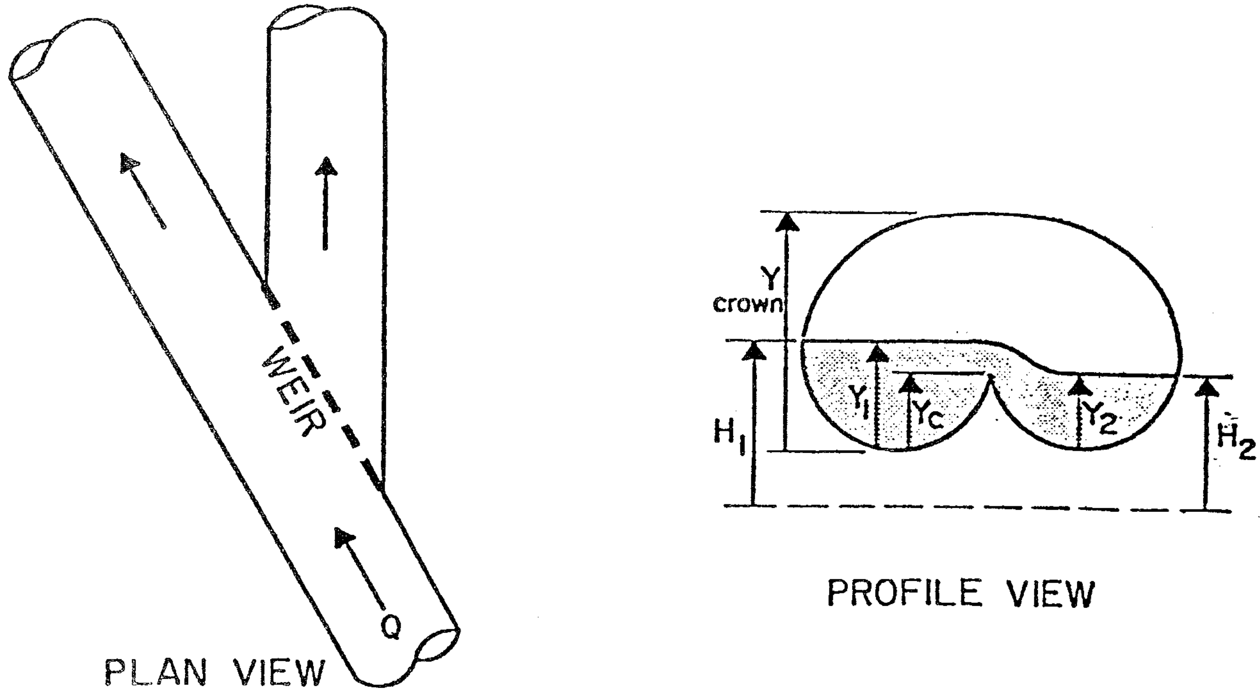
$$L = 2\ t\sqrt{gD} \qquad (3\text{-}23)$$

to insure that the celerity (stability) criterion for the pipe is not violated. The Manning n is then computed according to equation 3-22. This algorithm produces a solution to the orifice diversion that is not only as accurate as the orifice equation but also much more stable when the orifice junction is surcharged.

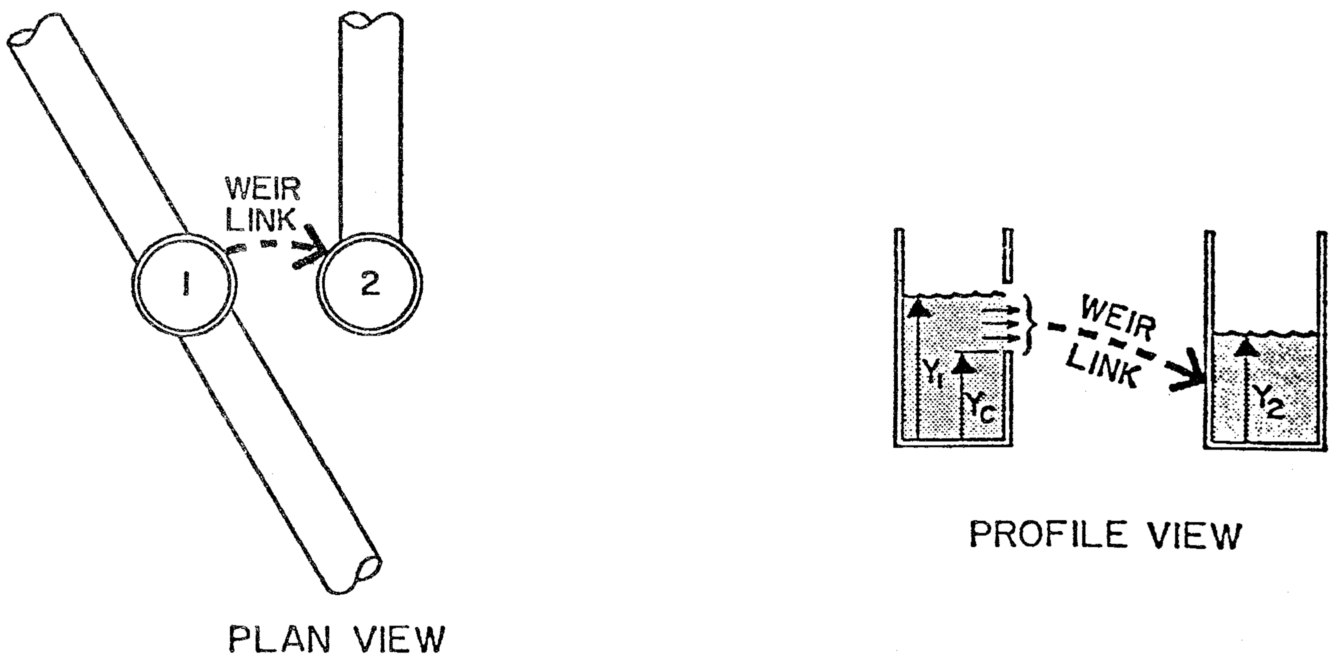
Weirs

A schematic illustration of flow transfer by weir diversion between two nodes is shown in Figure 3-7. Flow over a weir is computed by the equation:

$$Q_w = C_w L_w [(h + \frac{v^2}{2g})^a - (\frac{v^2}{2g})^a] \qquad (3\text{-}24)$$



Schematic of a Weir Diversion



Conceptual Representation of a Weir Diversion

FIGURE 3-7

REPRESENTATION OF WEIR DIVERSIONS

where

C_W = discharge coefficient;

L_W = weir length;

h = driving head on the weir;

v = approach velocity; and

a = weir exponent (3/2 for transverse weirs, 5/3 for sideflow weirs).

Both C_W and L_W are input values for transverse weirs. For sideflow weirs, C_W should be a function of the approach velocity, but the present version of the program does not provide for this because of the difficulty in defining the approach velocity. For this same reason, V, which is programmed into the weir solution, is set to zero prior to computing Q_W.

Normally, the driving head on the weir is computed as the difference $h = Y_1 - Y_C$, where Y_1 is the water depth on the upstream side of the weir and Y_C is the height of the weir crest above the node invert. However, if the downstream depth Y_2 also exceeds the weir crest height, the weir is submerged and the flow is computed by equation 3-25:

$$Q_W = C_{SUB}\, C_W L_W (Y_1 - Y_C)^{3/2} \qquad (3\text{-}25)$$

where C_{SUB} is a submergence coefficient representing the reduction in driving head and all other variables are as defined above.

The submergency coefficient, C_{SUB}, is taken from Roessert's Handbook of Hydraulics by interpolation from Table 3-3, where C_{RATIO} is defined as:

$$C_{RATIO} = \frac{Y_1 - Y_C}{Y_2 - Y_C} \qquad (3\text{-}26)$$

and all other variables are as previously defined.

The values of C_{RATIO} and C_{SUB} are computed automatically by ANALYSIS and no input data values are needed.

TABLE 3-3

VALUES OF C_{SUB} AS A FUNCTION OF DEGREE OF WEIR SUBMERGENCE

C_{RATIO}	C_{SUB}
0.00	1.00
0.10	0.99
0.20	0.98
0.30	0.97
0.40	0.96
0.50	0.95
0.60	0.94
0.70	0.91
0.80	0.85
0.85	0.80
0.90	0.68
0.95	0.40
1.00	0.00

If the weir is surcharged it will behave as an orifice and the flow is computed as:

$$Q_W = C_{SUR} L_W (Y_{TOP} - Y_c) \sqrt{2gh'} \qquad (3\text{-}27)$$

where

Y_{TOP} = distance to top of weir opening shown in Figure 4-2;

h' = Y_1 - maximum (Y_1, Y_c)

C_{SUR} = weir surcharge coefficient

The weir surcharge coefficient, C_{SUR}, is computed automatically at the beginning of surcharge. At the point where weir surcharge is detected, the preceding weir discharge just prior to surcharge is equated to Q_W in equation 3-26 and equation 3-27 is then solved for the surcharge coefficient, C_{SUR}. Thus, no input coefficient for surcharged weirs are required.

Finally, the present version of ANALYSIS detects flow reversals at weir nodes which causes the downstream water depth, Y_2, to exceed the upstream depth, Y_1. All equations in the weir section remain the same except that Y_1 and Y_2 are switched so that Y_1 remains as the "upstream" head. Also, flow reversal of a sideflow weir causes it to behave more like a transverse weir and consequently the exponent a in equation 3-24 is set to 1.5.

Weirs With Tide Gates

Weirs are sometimes installed together with a tide gate at points of discharge into the receiving waters. Flow across the weir is restricted by the tide gate, which may be partially closed at times. This is accounted for by reducing the effective driving head across the weir according to an empirical factor published by Armco (3):

$$h' = h - \frac{4}{g}v^2 e^{\frac{-1.15v}{\sqrt{h}}} \qquad (3\text{-}28)$$

where h is the previously computed head before correction for tide gate and v is the velocity of flow in the upstream conduit.

Pump Stations

A pump station is conceptually represented as either an in-line lift station or an off-line storage node (the wet-well) from which the contents are pumped to another node in the system according to a programmed rule curve. For an in-line lift station, the pump rate is based on the water depth at the pump junction. The rule is as follows:

$$\begin{aligned} \text{Pump Rate} &= R_1 \text{ for } 0 < Y < Y_1 \\ &= R_2 \text{ for } Y_1 < Y < Y_2 \\ &= R3 \text{ for } Y_2 < Y \end{aligned}$$

For Y = 0, the pump rate is the inflow rate to the pump junction.

Inflows to the off-line pump may be diverted from the main storm sewer system through an orifice, a weir, or a pipe with a free discharge condition at the storage node. The pumping rule curve is based on the volume of water in the storage junction. A schematic presentation of the pump rule is shown in Figure 3-8. The rule operates as follows:

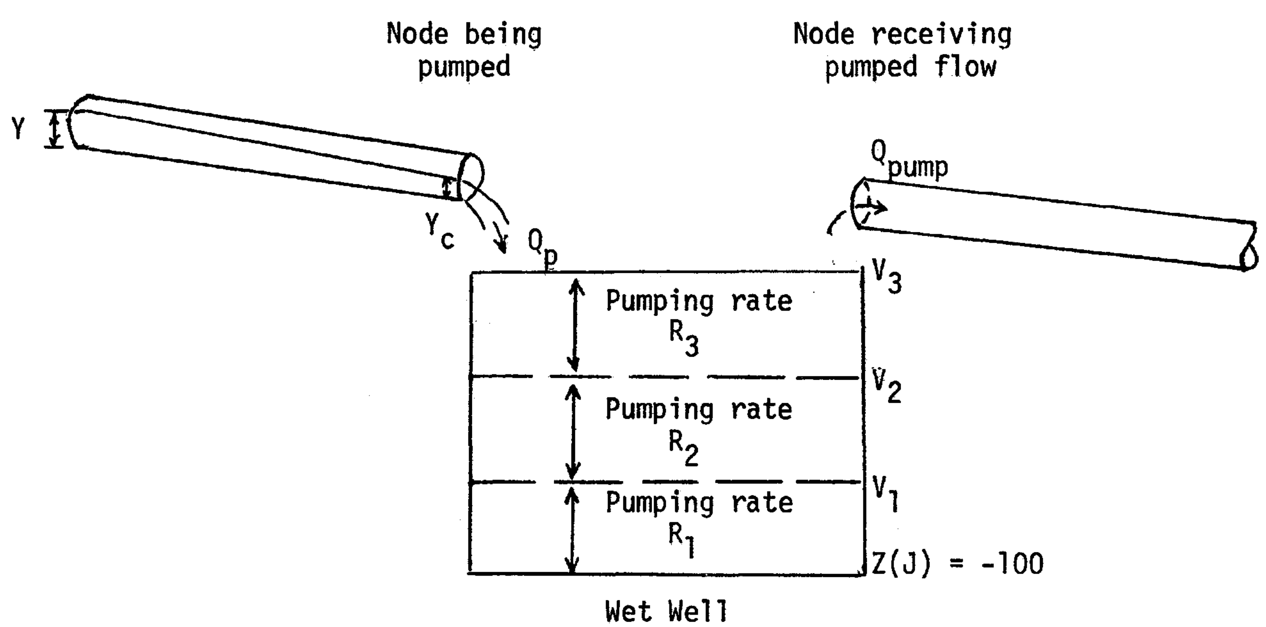
1. Up to three wet-well volumes are prespecified as input data for each pump station: $V_1 < V_2 < V_3$, where V_3 is the maximum capacity of the wet well.

2. Three pumping rates are prespecified as input data for each station. The pump rate is selected automatically by the Analysis Module depending on the volume in the wet-well as follows:
   R_1 for the volume in wet-well $< V_1$
   R_2 for $V_1 <$ volume in wet-well $< V_2$
   R_3 for $V_2 <$ volume in wet well $< V_3$

3. A mass balance of pumped outflow and inflow is performed in the wet-well during the model simulation period.

4. If the wet-well goes dry, the pump rate is reduced below rate R_1 until it just equals the inflow rate. When the inflow rate again equals or exceeds R_1, the pumping rate goes back to operating on the rule curve.

5. If V_3 is exceeded in the wet-well, the inflow to the storage node is reduced until it does not exceed the maximum pumped flow. Then the inflow falls below the maximum pumped flow, the inflow "gates" are opened again. The program automatically steps down the pumping rate by the operating rule as inflow and wet-well volume decrease.



Pumping rate = R_1 for $V < V_1$
= R_2 for $V_1 < V < V_2$
= R_3 for $V_2 < V < V_3$

V is volume in wet well

FIGURE 3-8

SCHEMATIC PRESENTATION OF OFF-LINE PUMP DIVERSION

Outfall Structures

ANALYSIS simulates both weir outfalls and free outfalls. Either type may be protected by a tide gate. A weir outfall is a weir which discharges directly to the receiving waters according to relationships given previously in the weir section. The free outfall is simply an outfall conduit which discharges to a receiving water body under given backwater conditions. The free outfall may be truly "free" if the elevation of the receiving waters is low enough, or it may consist of a backwater condition. In the former case, the water surface at the free outfall is taken as critical or normal depth, whichever is less. If backwater exists, the receiving water elevation is taken as the water surface elevation at the free outfall.

When there is a tide gate on an outfall conduit, a check is made to see whether or not the hydraulic head at the upstream end of the outfall pipe exceeds that outside the gate. If it does not, the discharge through the outfall is equated to zero. If the driving head is positive, the water surface elevation at the outfall junction is set in the same manner as that for a free outfall subjected to a backwater condition.

CHAPTER 4
USER's MANUAL

INTRODUCTION

When a drainage system is to be analyzed with the Analysis Module, the first step in the study is generally to define the storm sewer system and the watershed that it drains. Care should be taken in this step to insure that "as built" drawings are used of the system. Where information is suspect, a field investigation is in order.

Once the sewer system and watershed have been defined, the watershed is subdivided into subareas and runoff computed in accordance with the guidelines presented in the Surface Runoff Program User's Manual and Documentation Report. Conduits may be distinguished between those that can be simulated in the Drainage Design Program and those to be simulated in the Analysis Module. As a general rule, at least the upstream portions of the drainage system can be represented in the Drainage Design Program. The dividing point for application of the two programs is the point where backwater effects, surcharge, and/or diversion facilities affect the flow and head computation. Pipes and channels downstream of this point should be simulated with ANALYSIS.

Junction Points should be identified at each:

- Upstream terminal point in the system;
- Outfall and discharge point;
- Pump station, storage point, orifice and weir diversion;
- Junction where inflow hydrographs will be input (either by card input or from Program SRO);
- Pipe junction;
- Point where pipe size/shape changes significantly;
- Point where pipe slope changes significantly; and
- Point where pipe inverts are significantly different.

Following the preliminary identification of junction points, a check should be made to eliminate extremely long or short distances between junctions. As a rule of thumb, the longest conduit should not exceed four or five times the length of the shortest conduit. If this occurs, short conduits can be increased in length by use of equivalent pipes and long conduits can be shortened by adding intermediate junction points.

Keep in mind when setting conduit lengths (placing junctions or equivalent pipes) that the time-step is generally controlled by the wave celerity in the system. To estimate the time-step, first compute:

$$\Delta t_c = \frac{L}{\sqrt{gD}} \qquad (4\text{-}1)$$

where:

Δt_c = time for a surface wave to travel from one end of a conduit to the other in seconds;

L = conduit length in feet;

g = 32.2 ft/sec^2; and

D = channel depth or pipe diameter in feet.

The time-step can usually exceed Δt_c by a factor of 1.5 to 2.0 for a few widely separated conduits. For most problems, conduit lengths can be of such length that a 15 to 30 second time-step can be used. Occasionally a 5 to 10 second time-step is required. A time-step of 60 to 90 seconds should not be exceeded even in large open channel systems where the celerity criteria is not violated with a larger time-step.

If an extremely short pipe is included in the system, as indicated by a small Δt_c, an equivalent longer pipe can be developed using the following steps. First set the Manning equation for the pipe and its proposed equivalent equal:

$$\frac{1.49}{n_p} A_p R_p^{2/3} S_p^{1/2} = \frac{1.49}{n_e} A_e R_e^{2/3} S_e^{1/2} \qquad (4\text{-}2)$$

where:

p = actual pipe;

e = equivalent pipe;

n = Manning's roughness coefficient;

A = cross-sectional area;

R = hydraulic radius ; and

S = slope of the hydraulic grade line.

If we assume that the equivalent pipe will have the same cross-sectional area and hydraulic radius as the pipe it replaces, we can say:

$$S_p^{1/2}/n_p = S_e^{1/2}/n_e \tag{4-3}$$

Now, since

$$S = h_L/L \tag{4-4}$$

where:

h_L = the total head loss over the conduit length; and

L = conduit length,

and since the head losses are to be equal in both pipes, equation (4-2) can be simplified to:

$$n_e = n_p L_p^{1/2}/L_e^{1/2} \tag{4-5}$$

where L_e is the desired equivalent pipe length, either no smaller than four to five times smaller than the longest pipe in the system, or large enough to give a Δt_c within the range indicated above. The user through experience will be able to determine the pipe length changes required to achieve stability and an acceptable time-step for the simulation.

At this point, the system schematic should be in pretty good shape for developing model input data. The remaining sections of this chapter describe, step-by-step, how to develop the input data file for ANALYSIS.

INPUT REQUIREMENTS

Specifications for input data preparation are contained in Table 4-1. The table defines input format column location and variable description and name. Table 4-2, at the end of this section, is a set of input data forms which can be used to facilitate encoding the data for ANALYSIS. Perusal of Table 4-1 reveals that the input data is divided into 21 card groups. Card Groups 1-6 are control cards that identify the simulation, set the time-step and start time, and identify junctions for card input hydrograph, and junction and conduits for printing and plotting of heads and flows. The identification of conduits and junctions is done in Card Groups 7 and 8, respectively. Card Groups 9 - 12 identify storage and diversion junctions, while Groups 13 - 17 identify system outfalls and backwater conditions at the outfalls. Initial conditions for heads and flows are defined in Card Groups 18 - 19. Card Groups 20 and 21 define card input hydrographs. Further descriptions of the data to be entered in each card group are given below.

Card Group 1: Run Identification

Card Group 1 consists of 2 cards, each having 60 columns or less, which typically describe the system and the particular storm being simulated.

Card Group 2: Run Control

Card Group 2 is a single card defining the number of integration steps in the simulation period, the length of each time-step, output control data, and the number of hydrograph input points to be supplied by cards (in addition to, or rather than, tape input generated by the Surface Runoff Program).

TABLE 4-1. ANALYSIS DATA REQUIREMENTS

Card Group	Format	Card Columns	Description	Variable Name
			RUN TITLE	
1	15A4	1-60	Description of computer run (2 cards). Will be printed on output (2 lines).	ALPHA
			RUN CONTROL PARAMETERS	
2	I5,2F5.0, 9I5	1-5	Number of integration steps or time cycles desired	NTCYC
		6-10	Length of integration step, seconds	DELT
		11-15	Start time of simulation, decimal hours	TZERO
		16-20	Number of junctions for detailed printing of head output (20 nodes max.)	NHPRT
		21-25	Number of conduits for detailed printing of discharge output (20 pipes max.)	NQPRT
		26-30	Number of junctions to be plotted (20 max.)	NPLT
		31-35	Number of conduit flows to be plotted (20 max.)	LPLT
		36-40	First time-step to begin print cycle	NSTART
		41-45	Interval between print cycles (max. number of cycles printed is 100, $\therefore \frac{NTCYC - NSTART}{100} < INTER$)	INTER
		46-50	Number of input junctions, if card input hydrographs are used	NJSW
		51-55	Hydrograph file number from Surface Runoff Program	N21

TABLE 4-1. ANALYSIS DATA REQUIREMENTS
(Continued)

Card Group	Format	Card Columns	Description	Variable Name
			PRINTED HEADS	
3	8I10	1-10	First junction number for detailed printing	JPRT(1)
		11-20	Second junction number, up to number of nodes defined by NHPRT	JPRT(2)
			PRINTED FLOWS	
4	8I10	1-10	First conduit number for detailed printing	CPRT(1)
		11-20	Second conduit number up to number of nodes defined by NQPRT.	CPRT(2)
			PLOTTED HEADS	
		NOTE:	IF NPLT = 0, SKIP THIS CARD GROUP	
5	8I10	1-10	First junction number for plotting	JPLT(1)
		11-20	Second junction number, up to number of nodes defined by NPLT	JPLT(2)
			PLOTTED FLOWS	
		NOTE:	IF LPLT = 0, SKIP THIS CARD GOUP	
6	8I10	1-10	First conduit number for plotting	KPLT(1)
		11-20	Second conduit number for plotting, up to number of nodes defined by LPLT (This option is for conduit flow rate)	KPLT(2)
			CONDUIT CARDS(1 CARD/CONDUIT)	
7	415, 9F5.0	1-5	Conduit number (none greater than 90000)	NCOND(N)
		6-10	Junction number at one end of conduit upstream	NJUNC(N,1)
		11-15	Junction number at other end of conduit downstream	NJUNC(N,2)
		16-20	Type of conduit shape 1 = circular 2 = rectangular 3 = horseshoe 4 = egg 5 = baskethandle 6 = trapezoid	NKLASS(N)

TABLE 4-1. ANALYSIS DATA REQUIREMENTS
(Continued)

Card Group	Format	Card Columns	Description	Variable Name
7 (Continued)		21-25	Cross sectional area of conduit, sq. ft. (necessary only for types 3, 4, and 5)	AFULL(N)
		26-30	Vertical depth of conduit, ft.	DEEP(N)
		31-35	Maximum width of conduit, ft. Bottom width for trapezoid, ft.	WIDE(N)
		36-40	Length of conduit, ft.	LEN(N)
		41-45	Distance of conduit invert above junction invert at NJUNC(N,1)	ZP(N,1)
		46-50	Distance of conduit invert above junction invert at NJUNC(N,2)	ZP(N,2)
		51-55	Mannings coefficient (includes entrance and exit losses)	ROUGH(N)
		56-60	Slope of one side of trapezoid, (horizontal/vertical; 0=vertical	STHETA(N)
		61-65	Slope of other size of trapezoid (horizontal/vertical; 0=vertical	SPHI(N)
		(Last card must have 99999 in colums 1 to 5)		
			JUNCTION CARDS (1 CARD/JUNCTION)	
8	I5, 3F5.0	1-5	Junction number (none greater than 90000)	JUN(J)
		6-10	Ground elevation, ft.	GRELEV(J)
		11-15	Invert elevation, ft.	Z(J)
		16-20	Net constant flow into junction, cfs (optional - see text)	QINST(J)
		(Last card must have a 99999 in columns 1 to 5)		
			STORAGE JUNCTIONS (1 CARD/JUNCTION)	
		NOTE: JUNCTION MUST BE IDENTIFIED IN JUNCTION DATA		
9	I5, 2F5.0	1-5	Junction containing storage facility	JSTORE(I)
		6-10	Junction crown elevation (must be higher than crown of highest pipe connected to storage facility)	ZCROWN(J)
		11-15	Storage volume per foot of depth (surface area), cu. ft/ft.	ASTORE(I)
		(Last card must have a 99999 in columns 1 to 5)		

TABLE 4-1 ANALYSIS DATA REQUIREMENTS
(Continued)

Card Group	Format	Card Columns	Description	Variable Name
			ORIFICE CARDS (1 CARD/ORIFICE)	
10	3I5, 3F5.0	1-5	Junction containing storage facility	NJUNC(N,1)
		6-10	Junction to which orifice discharges	NJUNC(N,2)
		11-15	Type of orifice 1 = side outlet 2 = bottom outlet	NKLASS(N)
		16-20	Orifice area in sq. ft.	AORIF(I)
		21-25	Orifice discharge coefficient	CORIF(I)
		25-30	Distance of orifice invert above junction floor (define only for side outlet orifices)	ZP(I)
		(Last card must have 99999 in columns 1 to 5)		
			WEIR CARDS (1 CARD/WEIR)	
11	3I5, 4F5.0	1-5	Junction at which weir is located	NJUNC(N,1)
		6-10	Junction to which weir discharges NOTE: To designate outfall weir, set NJUNC(N,2) equal to zero	NJUNC(N,2)
		11-15	Type of weir 1 = transverse 2 = transverse with tide gates 3 = side flow 4 = side flow with tide gates	KWEIR(I)
		16-20	Height of weir crest above invert, ft.	YCREST(I)
		21-25	Height to top of weir opening above invert (surcharge level) ft.	YTOP(I)
		26-30	Weir length, ft.	WLEN(I)
		31-35	Coefficient of discharge for weir	COEF(I)
		(Last card must have a 99999 in columns 1 to 5)		
			PUMP CARDS (1 CARD/PUMP)	
		NOTE:	ONLY ONE PIPE CAN BE CONNECTED TO A PUMP NODE	
12	3I5, 7F5.0	1-5	Junction being pumped	NJUNC(N,1)
		6-10	Pump discharge goes to this junction	NJUNC(N,2)
		11-15	Type of pump 1 = off-line pump with wet well 2 = on-line lift pump	IPTYP(I)

TABLE 4-1. ANALYSIS DATA REQUIREMENTS
(Continued)

Card Group	Format	Card Columns	Description	Variable Name
12 (Continued)		16-20	Initial wet well volume, cu. ft. (enter 0 for type 2 pump)	VWELL(I)
		21-25	Lower pumping rate, cfs.	PRATE(I,1)
		26-30	Mid-pumping rate, cfs.	PRATE(I,2)
		31-35	High pumping rate, cfs.	PRATE(I,3)
		36-40	Wet well volume (or junction depth) for mid rate pumps to start, cu. ft. (or ft.)	VRATE(I,1)
		41-45	Wet well volume (or junction depth) for high rate pumps to start, cu. ft. (or ft.)	VRATE(I,2)
		46-50	Total wet well capacity, cu. ft. (enter 0 for type 2 pump)	VRATE(I,3)
		(Last card must have 99999 in columns 1 to 5)		
			OUTFALL PIPES W/O TIDE GATES (1 CARD OUTFALL)	
		NOTE:	ONLY ONE CONNECTING CONDUIT IS PERMITTED TO A FREE OUTFALL NODE	
13	I5	1-5	Junction for free outfall	JFREE(I)
		(Last card must have 99999 in columns 1 to 5)		
		OUTFALL PIPES WITH TIDE GATES (1 CARD OUTFALL)		
		NOTE:	ONLY ONE CONNECTING CONDUIT IS PERMITTED TO OUTFALL NODE.	
14	I5	1-5	Junction at which gate is located	JGATE(1)
		(Last card must have 99999 in columns 1 to 5)		
			1 CARD FOR TIDAL CONTROL	
15	I5, 8F5.0	1-5	Tide index: 1 = no water surface at outfalls 2 = outfall control water surface at constant elevation, A1 3 = tide coefficients provided 4 = program will compute tide coefficients	NTIDE
		6-10	First tide coefficient	A1
		NOTE:	COLUMNS 11-45 NOT REQUIRED UNLESS NTIDE = 3	
		11-15	Second tide coefficient	A2
		16-20	Third tide coefficient	A3

TABLE 4-1. ANALYSIS DATA REQUIREMENTS
(Continued)

Card Group	Format	Card Columns	Description	Variable Name
15 (Continued)		21-25	Fourth tide coefficient	A4
		26-30	Fifth tide coefficient	A5
		31-35	Sixth tide coefficient	A6
		36-40	Seventh tide coefficient	A7
		41-45	Tidal period in hours	W
			REQUIRED IF NTIDE = 4	
16	3I5	1-5	If one, there are four information points, program will develop the coefficients	KO
		6-10	Number of information points (4 if KO above above equals 1)	NI
		11-15	If one, will print information on tide coefficient development	NCHTID
			REQUIRED IF NTIDE = 4	
17	8F10.0	1-10	Time, first information points	TT(1)
		11-20	Tidal stage, at time above	YY(1)
		21-30	Time, second information points	TT(2)
		31-40	Tidal stage, at time above, up to number of points as defined by NI.	YY(2)
18	8F10.0	1-10	Initial dry weather flows (cfs)	Q(1)
		11-20	Initial dry weather velocities (fps)	V(1)
		21-30	NOTE: IF ALL INITIAL FLOWS, VELOCITIES AND HEADS ARE ZERO, PUNCH 99999. IN COLS. 1-10 OF FIRST CARD FOR Q(1). NO OTHER CARDS REQUIRED	Q(2)
		31-40		V(2)
		41-. ⋮		⋮
			(4 conduits per card, up to NTL conduits. Includes internal links.)	
19	8F10.0	1-10	Initial dry weather junction depth (ft.)	Y(1)
		11-20 ⋮	NOTE: SKIP IF A 99999. HAS BEEN PUNCHED FOR Q(1) ABOVE.	Y(2) ⋮
			(8 junctions per card up to NJ junctions. Includes internal junctions.)	Y(NJ)

TABLE 4-1. ANALYSIS DATA REQUIREMENTS
(Continued)

Card Group	Format	Card Columns	Description	Variable Name
			IF NJSW = 0, SKIP CARD GROUPS 20 AND 21	
20	16I5	1-5	First input node for card hydrograph	JSW(1)
		6-10	Second input node for card hydrograph	JSW(2)
			REQUIRED IF NJSW ≥ 1	
21	8F10.0	1-10	Clock time, in decimal hours	TEO
		11-20	Flow rate, cfs., first input node, JSW(1);	QCARD(1,1)
		21-30	Flow rate, cfs., second input node, JSW(2), up to NJSW nodes;	QCARD(2,1)
			(Repeat group 21 cards, final time on last group 21 card must be greater than end time of run.)	

The time-step, DELT, is most critical to the cost and stability of the ANALYSIS program run and must be selected carefully. The time-step should be selected according to the guidelines described in the Introduction to this chapter (see Equation 4-1). The computer program will check each conduit for violation of the surface wave criteria and will print the message:

**** WARNING **** (C*DELT/LEN) IN CONDUIT IS rrr AT FULL DEPTH

where rrr is the ratio

$$rrr = \frac{\Delta t\sqrt{gD}}{L} \qquad (4\text{-}6)$$

and

Δt = the time-step;

g = gravity;

D = conduit height or pipe diameter; and

L = conduit length.

As already noted, if rrr is greater than 1.5 or 2.0 for any conduit, or if several conduits have rrr over 1.5, the time-step should be reduced. rrr should never exceed 1.0 in a terminal conduit (i.e., an upstream terminal conduit or outfall).

Another constraint to be observed carefully is the length of the total simulation period defined as the product of NTCYC and DELT. This period must not extend in time beyond the simulation period of the Surface Runoff Program. Otherwise, an improper attempt to read beyond the end-of-file created by Program SRO is made and execution of ANALYSIS stops.

The printing interval, INTER, also must be specified carefully to insure proper output of heads, velocities, and flows. The present output capacity of ANALYSIS provides for 100 values each of nodal water depth, elevation, conduit flow and velocity to be printed as detailed output for any given simulation run. When this number is exceeded, the printing arrays are filled with extraneous results taken from other core storage locations which bear no resemblance to the desired output. As an example, if NTCYC = 1600 and we start printing in cycle 1(NSTART=1), then INTER must = 16 or more to maintain correct printing control. Alternatively if NSTART = 801, then INTER can be 8. Also, the output looks better if NSTART and INTER are selected so that the first (and subsequent) output(s) occurs at an even minute(s) or half minute(s).

Card Groups 3 and 4: Detailed Printing for Junctions and Conduits

Card Group 3 contains the list of individual junctions (up to 20) for which water depth and water surface elevations are to be printed continuously throughout the course of the simulation period. Card Group 4 contains the list of individual conduits (up to 20) for which flows and velocities are to be printed.

Card Groups 5 and 6: Detailed Plotting for Junctions and Conduits

Card Groups 5 and 6 contain, respectively, the lists of junctions and conduits for which time histories of water surface elevation and flows are to be plotted.

Card Group 7: Conduit Data

Card Group 7 contains data input specification for conduits including shape, size, length, hydraulic roughness, connecting junctions, and invert distances referenced from the junction invert. The input data instructions, as presented in Table 4-1, are self-explanatory with the exception of junction/conduit invert elevations.

Basic definitions of conduit invert distances ZP(N,1) and ZP(N,2) are illustrated in Figure 4-1. The junction invert elevation is specified in Card Group 8. The distance ZP is height of the invert of connecting conduits

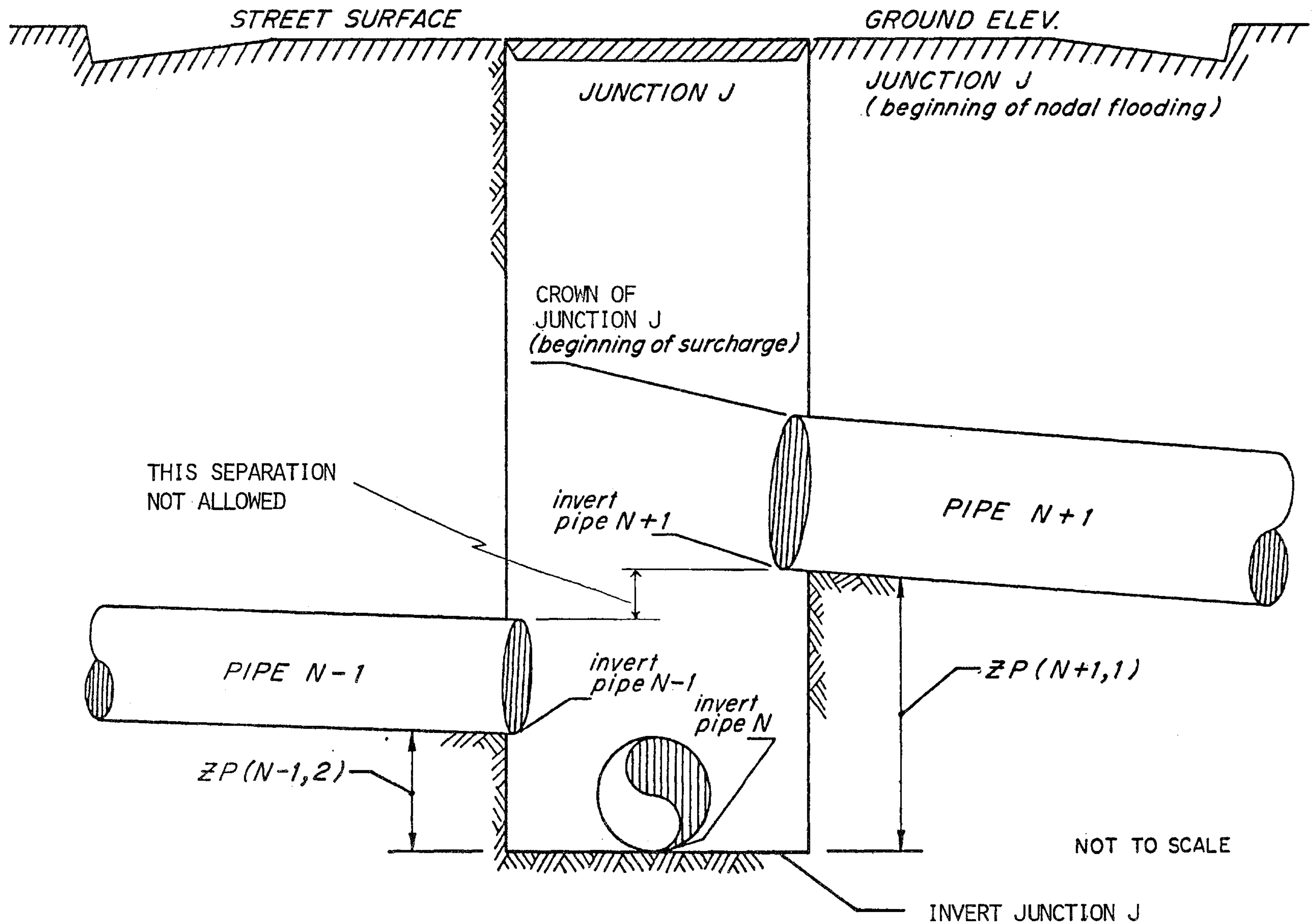


FIGURE 4-1. DEFINITION OF ELEVATION TERMS FOR THREE-PIPE JUNCTION

above the junction floor. Note, however, that the lowest pipe connected to the junction (pipe N in Figure 4-1) must have a ZP of zero. If it does not, the junction will behave like a mass sink in the system. Water will flow into the junction but none will flow out.

It should be noted that the Manning n includes not only friction loss in the conduit but also any entrance, exit, and bend losses that might occur in the conduit. Also the conduit data should reflect the substitution of any equivalent pipes which have been made for stability purposes.

Card Group 8: Junction Data

The explanation of ground and invert elevations is also shown in Figure 4-1. One junction card is required for every junction in the network including: regular junctions; storage and diversion junctions; pump junctions; and outfall junctions. It is emphasized again that the junction invert elevation is defined as the invert elevation of the lowest pipe connected to the junction. The program execution will terminate with an error message:

**** ERROR **** ALL CONDIUTS CONNECTING TO JUNCTION __
LIE ABOVE THE JUNCTION INVERT

unless there is at least one pipe having a zero ZP at the junction.

The surcharge level or junction crown elevation is defined as the crown elevation of the highest connecting pipe and is computed automatically by ANALYSIS. Note that the junction must not surcharge except when the water surface elevation exceeds the crown of the highest pipe connected to the junction. Pipe N+1 in Figure 4-1 is too high. This junction would go into surcharge during the period when the water surface is between the crown of pipe N-1 and the invert of pipe N+1. If a junction is specified as shown in Figure 4-1 and the water surface rises above the crown of pipe N-1, the program will print an error message:

**** ERROR **** SURFACE AREA AT JUNCTION ___ IS ZERO,
CHECK FOR HIGH PIPE

and will then stop. To correct this situation, a new junction should be specified that connects to pipe N+1. A "dummy conduit" is specified which connects the old junction with pipes N-1 and N to the new junction which connects to pipe N+1. The pipe diameter should be that of N+1 and the length selected to meet the stability criteria given by equation 4-6. The Manning n for the "dummy pipe" is computed to reflect the energy loss that occurs during surcharge as water moves up through the manhole and into pipe N+1.

The "ground elevation", GRELEV(J), is the elevation at which the assumption of pressure flow is no longer valid. Normally, this will be the street or ground elevation; however, if the manholes are bolted down, the GRELEV(J) should be set sufficiently high so that the simulated water surface elevation does not exceed it. When the hydraulic head must exceed GRELEV(J) to maintain continuity at the junction, the program allows the excess junction inflow to "overflow onto the ground" and become lost from the system for the remainder of the simulation period.

QINST(J) is the net constant flow entering (positive) or leaving (negative) the junction. This variable need be supplied only in those very rare instances when a source of some constant flow, during both dry-weather and wet-weather conditions, is present.

Card Group 9: Storage Junctions

Conceptually, storage junctions are tanks of constant surface area over their depth. A storage "tank" may be placed at any junction in the system, either in-line or off-line. The elevation of the top of the tank is specified in the storage junction data and must be at least as high as the highest pipe crown at the junction. If this condition is violated, the system will go into simulated surcharge before the highest pipe is flowing full.

Card Group 10: Orifice Cards

The Analysis Module simulates orifices as equivalent pipes (see Chapter 3). Data entry is straightforward. For sump orifices, the program automatically sets the invert of the orifice one diameter <u>below</u> the junction invert so that the orifice is flowing full before there is any discharge to conduits downstream of the junction containing the orifice.

Card Group 11: Weir Cards

The definition sketch for weirs is illustrated in Figure 4-2. The following types of weirs can be simulated:

- Internal diversions (from one junction to another) via a transverse or sideflow weir.
- Outfall weirs which discharge to the receiving waters. These weirs may be transverse or sideflow types, and may be equipped with flap gates that prevent backflow.

Transverse weir and sideflow weirs are distinguished in ANALYSIS by the value of the exponent to which the head on the weir is taken. For transverse weirs, head is taken to the 3/2 power (i.e., $Q_W \sim H^{3/2}$) while for sideflow weirs the exponent is 5/3 (i.e., $Q_W \sim H^{5/3}$).

When the water depth at the weir junction exceeds YTOP (see Figure 4-2) the weir functions as an orifice ($Q_W \sim H^{1/2}$). The discharge coefficient for the orifice flow condition is computed internally in ANALYSIS (see Chapter 3).

Stability problems can be encountered at a weir junction if the junction surcharges during the simulation. If this happens or is suspected of happening, the weir may be represented as an equivalent pipe. To do this, equate the pipe and weir discharge equations, e.g.:

$$\frac{1.49}{n} AR^{2/3}S^{1/2} = C_W W H^{3/2} \qquad (4\text{-}7)$$

where:

n = Manning n for the pipe;

A = Cross-sectional area;

R = Hydraulic radius;

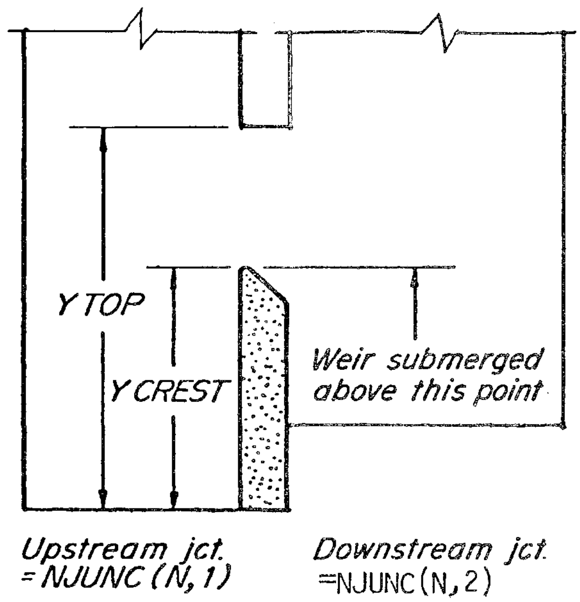


FIGURE 4-2. DEFINITION SKETCH OF WEIR INPUT DATA

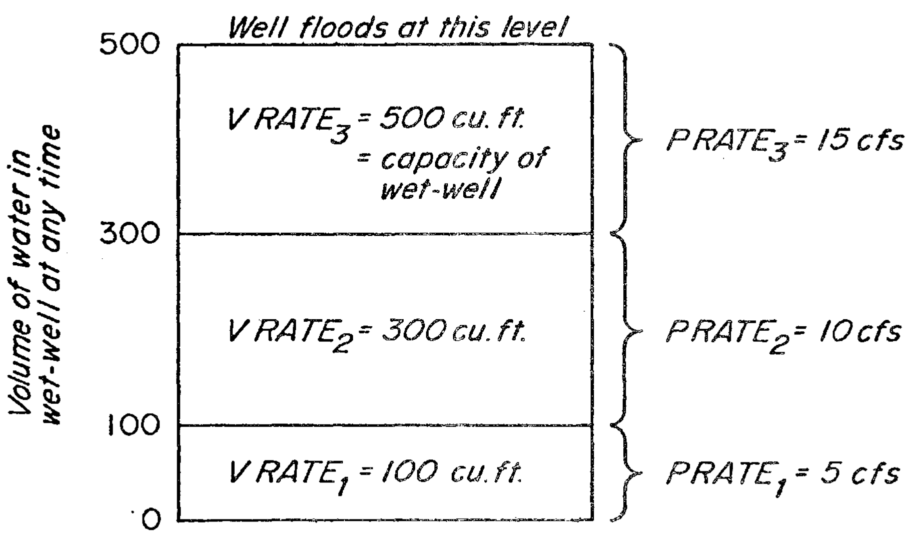


FIGURE 4-3. DEFINITION SKETCH OF PUMP INPUT DATA

S = hydraulic grade line for the pipe;

H = head across the weir;

C_w = weir discharge coefficient; and

W = weir length.

In this equation, $S = H/L$ where L is the pipe length, and $A = WH$. If R is set at the value of the hydraulic radius where the head is half way between YCREST and YTOP, and L is set in accordance with Equation 4-6, then n can be computed as:

$$n = \frac{R^{2/3}}{C_w L^{1/2}} \tag{4-8}$$

for the equivalent pipe.

Card Group 12: Pump Cards

Pumps may be of two types:

1. An off-line pump station with a wet well; the rate of pumping depends upon the volume (level) of water in the wet well.
2. An on-line lift station that pumps according to the level of the water surface at the junction being pumped.

The definition sketch in Figure 4-3 defines the input variable for Type 1 pump.

For a Type 2 pump station, the following operating rule is used:

$Y \leq$ VRATE(I,1)	Q_p = Junction inflow or PRATE(I,1), whichever is less
VRATE(I,L) < $Y \leq$ VRATE(I,2)	Q_p = PRATE(I,2)
VRATE(I,2) < Y	Q_p = PRATE(I,3)

Note that for a Type 2 pump station VRATE is the water depth at the pump junction, while for a Type 1 station it is the volume of water in the wet well.

Note also that only one conduit may be connected to a pumped junction.

Card Group 13: Free Outfall Pipes

Three types of outfalls can be simulated in the Analysis Module:

1. A weir outfall with or without a flap (tide) gate (See Card Group 11);
2. A conduit outfall without a flap gate (Card Group 13); or
3. A conduit outfall with a flap (tide) gate (Card Group 14).

Under Card Group 13, enter the outfall junction number for outfall conduits without flap gates.

Card Group 14: Outfall Pipes With Flap Gates

Enter the outfall junction number for conduits with flap gates.

Card Groups 15, 16, and 17: Tidal Backwater Control Cards

Card groups 15, 16, and 17 describe the single tidal backwater condition which is applied at all outfalls in the drainage system. The tidal index, NTIDE, is specified according to whether there is: (1) no water surface at any outfall; (2) a water surface at constant elevation; (3) a tide whose period and amplitude are described by user supplied tide coefficients; or (4) a tide which will be computed by ANALYSIS based on a specified number of stage-time points describing a single tidal cycle.

Card Groups 18 and 19: Initial Flows, Velocities, and Heads

It is sometimes desired to initialize the drainage network with starting values of flow, velocity, and water surface elevation which can represent antecedent flow conditions just prior to the storm to be simulated. Card Groups 18 and 19 are designed for the purpose of supplying these initial conditions throughout the drainage system at the beginning of the simulation.

Card Group 18 contains discharge for each conduit in the same order as it is specified in Card Group 8. Note that initial discharge must be specified for all real conduits plus all internal links. (There is one internal link for each orifice, weir, pump, and outfall in the system. In a complex network, the total number of real plus internal conduits is best determined from the conduit connectivity summary in a trial run with ANALYSIS.) As an example, in a system of 25 real conduits, 28 junctions, 2 orifices, 3 weirs, and 1 free outfall, we have a total of 31 links. The specification of initial discharges in Card Group 18 requires a total of 8 cards with 4 conduits on each. For the case where all flows and heads are zero at the start of the simulation, enter 99999. in columns 5 thru 10 of Card Group 18.

Similarly, initial depths of flow (not elevations) are keypunched according to the instruction in Card Group 19. Again the initial heads are supplied for all real and internal junctions. The latter are specified automatically by the Analysis Module for each weir in the system. Thus in the example above, we would have a total of 31 junctions and the initial dry-weather heads would be punched on four cards in the order the junctions appear in Card Group 9.

Card Groups 20 and 21: Hydrograph Input Cards

ANALYSIS provides for input of up to 20 inflow hydrographs by cards in cases where it is desirable to run ANALYSIS alone without prior use of the Surface Runoff Program or to add additional input hydrographs to those computed by the Surface Runoff Program. The specification of individual junctions receiving hydrograph input by cards is given in Card Group 20. Note that multiple hydrographs coming into a given junction can be indicated by repeating the junction number in Group 21 for each inflow hydrograph. The order of hydrograph time discharge points in Card Group 21 now must correspond exactly with the order specified by Card Group 20. The time, TEO, of each discharge point is given in decimal clock hours; i.e., 10:45 a.m. is punched as 10.75. The last card in Group 21 must have a time, TEO, in decimal hours beyond the length of the simulation period in order to terminate hydrograph input. This is the final card in the input data for ANALYSIS. An example of input data is contained later in this chapter.

TABLE 4-2

DATA INPUT FORM

ANALYSIS

A set of input data forms which can be used to facilitate encoding the data for analysis are presented on pages 67 to 82. The input data is divided into 21 card groups:

Card Groups 1 to 6 are control cards.

Card Groups 7 to 17 are identification cards for conduits, junctions, storage, diversions junctions, system outfalls and backwater conditions at the outfalls.

Card Groups 18 and 19 define initial conditions for heads and flows.

Card Groups 20 and 21 define input hydrographs.

DATA INPUT FORM
ANALYSIS

Card Group 1 of 21: Title cards (2 cards)
Format: 15A4

ALPHA	

Card Group 2 of 21: Run control card
Format: I5, 2F5.0, 9I5

NTCYC	DELT	TZERO	NHPRT	NQPRT	NPLT	LPLT	NSTART	INTER	NJSW	N21	N22			

Card Group 3 of 21: Junction print control (8 junctions per card)
Format: 8I10

JPRT (1)	JPRT (2)	JPRT (3)	JPRT (4)	JPRT (5)	JPRT (6)	JPRT (7)	JPRT (8)

Card Group 4 of 21: Conduit print control (8 conduits per card)
Format: 8I10

CPRT (1)	CPRT (2)	CPRT (3)	CPRT (4)	CPRT (5)	CPRT (6)	CPRT (7)	CPRT (8)

DATA INPUT FORM
ANALYSIS

Card Group 5 of 21: Junction plot control (8 junctions per card)
Format: 8I10

JPLT (1)	JPLT (2)	JPLT (3)	JPLT (4)	JPLT (5)	JPLT (6)	JPLT (7)	JPLT (8)

DATA INPUT FORM
ANALYSIS

Card Group 6 of 21: Conduit plot control (8 conduits per card)
Format: 8I10

KPLT (1)	KPLT (2)	KPLT (3)	KPLT (4)	KPLT (5)	KPLT (6)	KPLT (7)	KPLT (8)

DATA INPUT FORM
ANALYSIS

Card Group 7 of 21: Conduit cards (1 card per conduit)
Format: 4I5, 9F5.0

NCOND	NJUNC UPSTR	NJUNC DNSTR	NKLASS	AFULL SQ FT	DEEP FT	WIDE FT	LEN FT	ZP UPSTR	ZP DNSTR	ROUGH	SIDE SLOPE 1	SIDE SLOPE 2	

NOTE: Last card must be 99999 in columns 1-5

DATA INPUT FORM
ANALYSIS

Card Group 8 of 21: Junction cards (1 card per junction)
Format: I5, 3F5.0

JUN	GRELEV	Z	QINST	

NOTE: Last card must be 99999 in columns 1-5

DATA INPUT FORM
ANALYSIS

Card Group 9 of 21: Storage cards (1 card per junction)
Format: I5, 2F5.0

JSTORE	ZTOP	ASTORE ft^2	

DATA INPUT FORM
ANALYSIS

Card Group 10 of 21: Orifice cards (1 card per orifice)
Format: 3I5, 3F5.0

$NJUNC_1$	$NJUNC_2$	NKLASS	AORIF	CORIF	ZP	

NOTE: Last card must be 99999 in columns 1-5

DATA INPUT FORM
ANALYSIS

Card Group 11 of 21: Weir cards (1 card per weir)
Format: 3I5, 4F5.0

$NJUNC_1$	$NJUNC_2$	KWEIR	YCREST	YTOP	WLEN	COEF	

NOTE: Last card must be 99999 in columns 1-5

DATA INPUT FORM
ANALYSIS

Card Group 12 of 21: Pump cards (1 card per pump)
Format: 3I5, 7F5.0

$NJUNC_1$	$NJUNC_2$	IPTYP	VWELL	$PRATE_1$	$PRATE_2$	$PRATE_3$	$VRATE_1$	$VRATE_2$	$VRATE_3$	

NOTE: Last card must be 99999 in columns 1-5

DATA INPUT FORM
ANALYSIS

Card Group 13 of 21: Free outfall cards (1 card per outfall)
Format: I5

JFREE

NOTE: Last card must be 99999 in columns 1-5

DATA INPUT FORM
ANALYSIS

Card Group 14 of 21: Outfalls with tide gates (1 card per outfall)
Format: I5

JGATE	

NOTE: Last card must be 99999 in columns 1-5

DATA INPUT FORM
ANALYSIS

Card Group 15 of 21: Tide control card (1 card)
Format: I5, 8F5.0
Card Group 16 of 21: Tide computation card (1 card)
Format: 3I5
Card Group 17 of 21: Tide stage card (4 points per card)
Format: 8F10.0

NTIDE	A1	A2	A3	A4	A5	A6	A7	W

KO	N1	NCHTID

TT_1	YY_1	TT_2	YY_2	TT_3	YY_3	TT_4	YY_4

DATA INPUT FORM

ANALYSIS

Card Group 18 of 21: Initial flows and velocities (4 conduits per card)
Format: 8F10.0

Q_1	V_1	Q_2	V_2	Q_3	V_3	Q_4	V_4

NOTE: If initial condition is zero flow throughout entire system, punch 99999. for Q_1. No other cards required.

DATA INPUT FORM
ANALYSIS

Card Group 19 of 21: Initial heads (8 junctions per card)
Format: 8F10.0

Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8

NOTE: If Q(I) is 99999, indicating zero flow, skip Card Group 19.

DATA INPUT FORM
ANALYSIS

Card Group 20 of 21: Hydrograph input control cards (16 input nodes per card)
Format: 16I5

JSW(1)	JSW(2)	JSW(3)	JSW(4)	JSW(5)	JSW(6)	JSW(7)	JSW(8)	JSW(9)	JSW(10)	JSW(11)	JSW(12)	JSW(13)	JSW(14)	JSW(15)	JSW(16)

DATA INPUT FORM
ANALYSIS

Card Group 21 of 21: Hydrograph inflow cards (7 flows per card at time TEO)
Format: 8F10.0

TEO	QCARD(1)	QCARD(2)	QCARD(3)	QCARD(4)	QCARD(5)	QCARD(6)	QCARD(7)

TIPS FOR TROUBLE-SHOOTING

In the preceding section of this user's manual, we described in detail the individual data input elements for the Analysis Module. We believe that careful study of the data input instructions, together with the example problem presented later in this chapter will go a long way in answering the usual questions of "how to get started" in using a computerized stormwater model as intricate as this one.

Obviously, it is not possible to anticipate all problems in advance and therefore certain questions are bound to occur in the user's initial attempts at application. The purpose of this section is to offer a set of guidelines and recommendations for setting up ANALYSIS which will help to reduce the number of problem areas and thereby alleviate frequently encountered start-up pains.

Most difficulties in using the Analysis Module arise from three sources: (1) improper selection of time step and incorrect specification of the total simulation period; (2) incorrect print and plot control variables; and (3) improper system connectivity in the model. These and other problem areas are discussed below.

Numerical stability constraints in the Analysis Module require that DELT, the time step, be no longer than the time it takes flow to travel the length of the shortest conduit in the transport system. A 10-second time step is recommended for most wet-weather runs. The numerical stability criteria for the explicit finite-difference scheme used by the model are discussed earlier in this chapter.

Numerical instability in ANALYSIS is signaled by the occurrence of the following hydraulic indicators:

1. Oscillations in flow and water surface elevation which are undampened in time are sure signs of numerical instability. Certain combinations of pipe and weir structures may cause temporary resonance, but this is normally short-lived. The unstable pipe usually is short relative to other adjacent pipes and may be subject to backwater created by a downstream weir. The correction is a shorter time step, a longer pipe length or combination of both. Neither of these should be applied until a careful check of system connections on all sides of the unstable pipe has been made as suggested below.

2. A second indicator of numerical instability is a node which continues to "dry up" on each time step despite a constant or increasing inflow from upstream sources. The cause usually is too large a time step and excessive discharges in adjacent downstream pipe elements which pull the upstream water surface down. The problem is related to items (1) and (3) and may usually be corrected by a smaller time step.

3. Excessive velocities (over 20 fps) and discharges which appear to grow without limit at some point in the simulation run are manifestations of an unstable pipe element in the transport system. The cause usually can be traced to the first source above and the corrections are normally applied as suggested in item (1) above.

The simulation period is defined by the product NTCYC x DELT or the number of integration cycles times the length of each cycle. If this product exceeds the simulation period of Surface Runoff Program input tape an illegal end-of-file is encountered and execution stops. NTCYC must then be reduced to correspond with the Surface Runoff Program simulation period.

The length of all conduits in the transport system should be roughly constant and no less than 100 feet. This constraint may be difficult to meet in the vicinity of weirs and abrupt changes in pipe configurations which must be represented in the model. However, the length of the shortest conduit does directly determine the maximum time step and the number of pipe elements, both of which in turn control the cost of simulation. The use of longer pipes should be facilitated through use of equivalent sections and slopes in cases where significant changes must be represented in the model.

In ANALYSIS, printed output can be requested for a maximum of 20 nodes and conduits. In addition, the number of printed points for a given node or conduit is automatically set at 100 regardless of the length of simulation. This requires that the print frequency control variable INTER is defined strictly by the criterion:

$$\frac{\text{NTCYC} - \text{NSTART}}{\text{INTER}} \leq 100$$

where all variables are as defined in this chapter. If, for example, NTCYC = 1600 and NSTART = 9 and the user selects INTER = 10, then the ratio (NTCYC - NSTART) ÷ INTER = 159. Because the 100-value printing arrays would then be filled with 159 values, an overflow situation would occur thereby producing output which is badly scrambled at best and unusable at worst. Therefore, it is worthwhile to look closely at INTER prior to any major transport run.

Prior to a lengthy run of the Analysis Module for a new system, a short test run of perhaps five integration cycles should be made to confirm that the link-node model is properly connected and correctly represents the prototype. This check should be made of the echo printed data showing respectively the connecting nodes for each pipe and the connecting conduits for each node. The geometric-hydraulic data for each pipe and junction should also be confirmed. Particular attention should be paid to the nodal location of weirs, orifices, and outfalls to ensure these conform to the prototype system. In addition, the total number of conduits and junctions, including internal links and nodes created, can be determined from the Internal Connectivity Table. This information is necessary for proper specification of initial heads and flows at time zero in the simulation.

The introduction of a ZP invert elevation difference for all pipes connecting a single junction will cause the junction invert elevation to be incorrectly specified. This in turn will create errors in hydraulic computation later in the simulation. The junction invert must be at the same elevation as the invert of the lowest pipe either entering or leaving the junction or it is improperly defined. This problem is readily corrected by checking the punched conduit data cards to determine where a non-zero ZP should be set to zero.

PROGRAM DESCRIPTION

General

The Analysis Module is a set of computer subroutines which are organized to simulate the unsteady, gradually-varied movement of stormwater in a sewer network composed of conduits, pipe junctions, diversion structures, and free outfalls. A program flowchart for the major computation steps in the Analysis Module is presented in Figure 4-4.

The Analysis Module contains 12 subroutines in addition to the main program which controls execution. The organization of each subroutine and its relation to the main program has been diagrammed in the master flowchart of Figure 4-5. A description of each subroutine follows in the paragraphs below.

Program MAIN

MAIN is the main program of the Analysis Module which drives all other subprograms and effectively controls the execution of ANALYSIS as it has been presented graphically in the flowchart of Figure 4-4. Principal steps in MAIN are outlined below in the order of their execution:

1. Call INDATA for reading all input data cards defining the length of the simulation run, the physical data for the storm sewer system, and the instruction for output processing.
2. Initialize system flow properties and set time = TZERO.

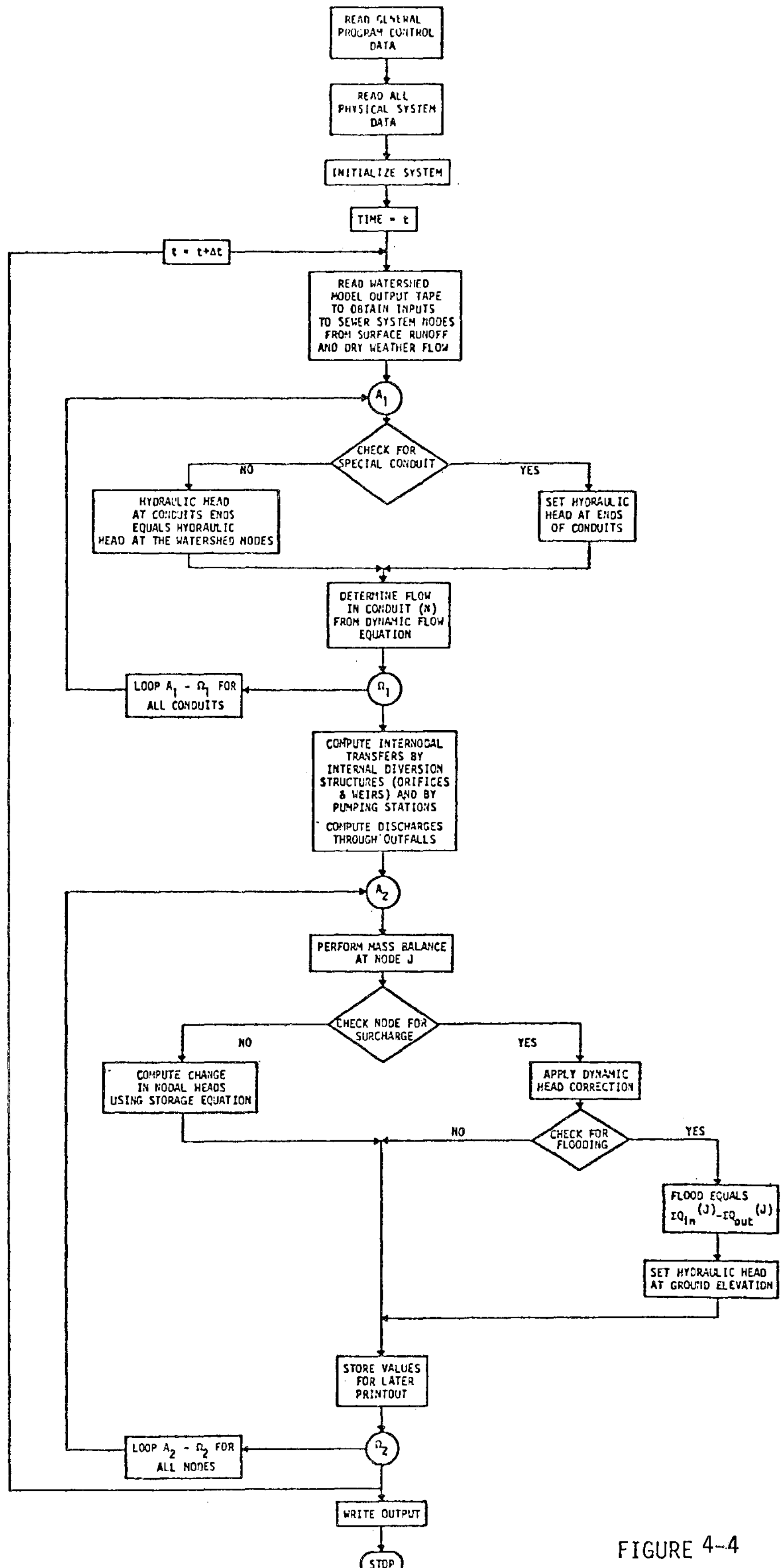


FIGURE 4-4
ANALYSIS MODULE FLOWCHART

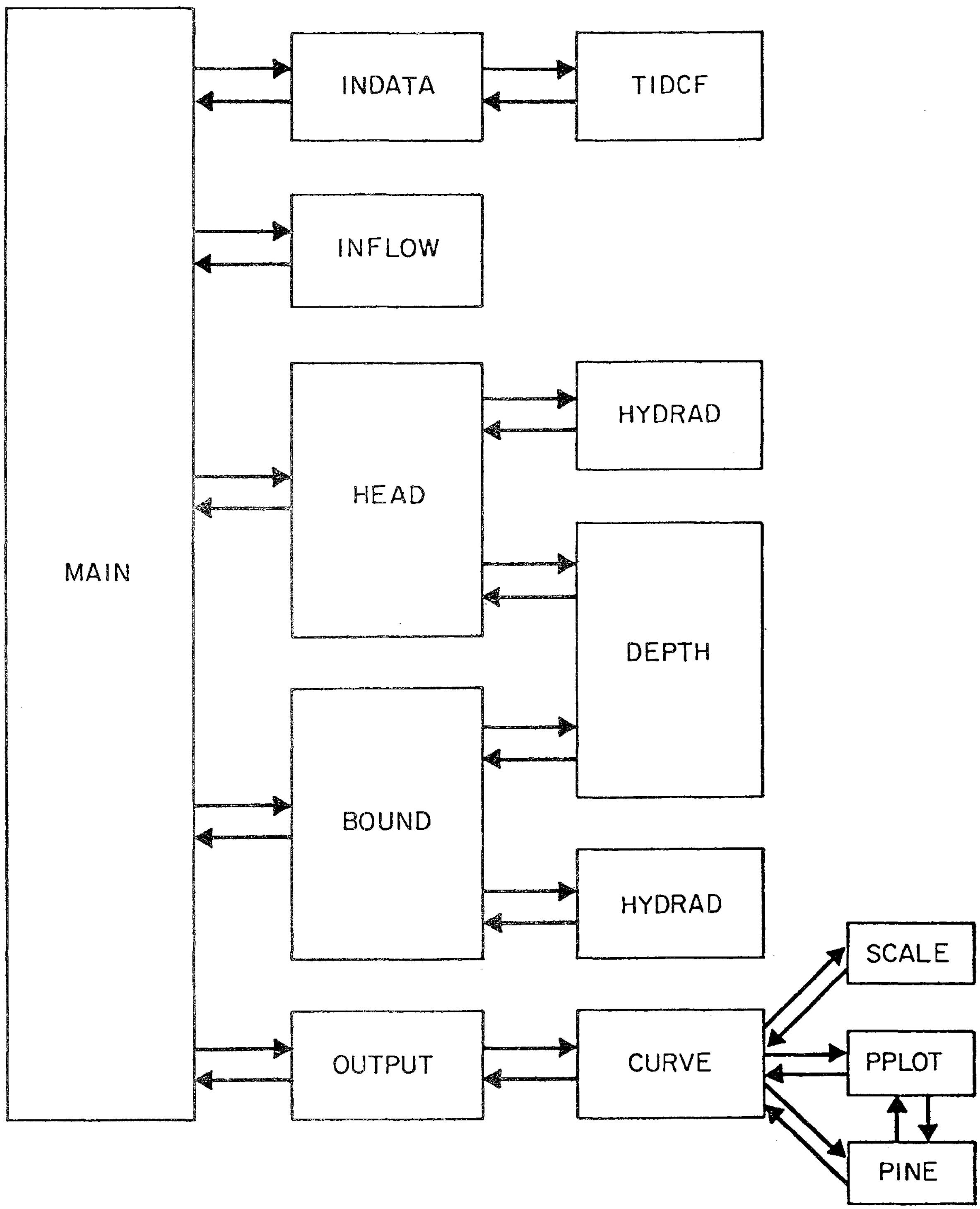


FIGURE 4-5
MASTER FLOWCHART FOR THE ANALYSIS MODULE

3. Advance time = $t+\Delta t$ and begin main computation loop contained in steps 4 through 9 below.

4. Select current value of inflow hydrographs for all input nodes by call to INFLOW, which interpolates runoff hydrograph records either on tape unit N21 supplied by the Surface Runoff Program or on data cards.

5. For all physical conduits in the system, compute the following time-changing properties based on the last full-step values of depth and flow:

   - Hydraulic head at each pipe end;
   - Full-step values of cross-sectional area, velocity, hydraulic radius, and surface area corresponding to preceding full-step flow. (This is done by calling subroutine HEAD);
   - Half-step value of discharge at time $t=t+\Delta t/2$ by modified Euler solution;
   - Check for normal flow if appropriate; and
   - Set system outflows and internal transfers at time $t+\Delta t/2$ by call to subroutine BOUND. (BOUND computes the half-step flow transfers at all orifices, weirs, and pumps at time $t=t+\Delta t/2$. It also computes the current value of tidal stage and the half-step value of depth and discharge at all outfalls.)

6. For all physical junctions in the system compute the half-step depth at time $t=t+\Delta t/2$. This depth computation is based on the current net inflows to each node and the nodal surface areas computed previously in step 5. Check for surcharge and flooding at each node and compute water depth accordingly.

7. For all physical conduits, compute the following properties based on the last half-step values of depth and flow (repeat step 5 for time $t+\Delta t/2$:
   - Hydraulic head at each pipe end;
   - Half-step values of pipe cross-sectional area, velocity, hydraulic radius, and surface area corresponding to preceding half-step depth and discharge;
   - Full-step discharge at time $t+\Delta t$ by modified Euler solution;
   - Check for normal flow if appropriate; and
   - Set system outflows and internal transfer at time $t+\Delta t$ by calling BOUND.
8. For all junctions, repeat the nodal head computation of step 6 for time $t+\Delta t$.
9. Store nodal water depths and water surface in junction print arrays to be used later by OUTPUT. Also store conduit discharges and velocities for later printing. Print intermediate output.
10. Return to step 3 and repeat through step 9 until the simulation is complete for the entire period.
11. Call subroutine OUTPUT for printing and plotting of conduit flows and junction water surface elevations.

A computer listing of MAIN follows.

Subroutine BOUND

The function of subroutine BOUND is to compute the half-step and full-step flow transfers by orifices, weirs, and pump stations. BOUND also computes the current level of receiving water backwater and determines discharge through system outfalls. The computer listing of this subroutine is given below. A summary of principal calculations follows:

```
C                  THIS IS THE MAIN PROGRAM OF THE SEWER MODEL
C                  IT DRIVES ALL SUBPROGRAMS AND PERFORMS THE
C                  MODIFIED EULER SOLUTION OF THE MOTION
C                  AND CONTINUITY EQUATIONS
C
      COMMON /BD/ANORM(26,5),HRNORM(26,5),TWNORM(26,5)
C
C
      COMMON/HYFLOW/ ISW(187),QTAPE(187,2),JSW(65),QCARD(65,2),
     1 WATSH(187),TEO,TP,T2,TE,T20,TIMEO,NSTEPS,NINREC
        COMMON/FILES/ N5,N6,N21,N22,NPOLL
      COMMON/CONTR/ NTCYC,DELTQ,DELT,DELT2,TZERO,ALPHA(30),
     1 NJ,NC,NTC,NTL,ICYC,NJSW,MJSW,TIME,TIME2,A1,A2,A3,A4,A5,A6,A7,W
      COMMON/JUNC/Y(187),YT(187),NCHAN(187,8),AS(187),Z(187),QIN(187),
     1 QOU(187),QINST(187),GRELEV(187),JUN(187),ZCROWN(187),JSKIP(187)
     2 ,SUMAL(187),SUMQ(187),SUMQS(187),ASFULL(187)
C
      COMMON/PIPE/LEN(187),NJUNC(187,2),AFULL(187),AT(187),
     1 Q(187),V(187),VT(187),DEEP(187),A(187),WIDE(187),RFULL(187),
     2 NKLASS(187),ZP(187,2),QT(187),QO(187),H(187,2),NCOND(187),
     3 ROUGH(187)
      COMMON/TRAP/STHETA(200),SPHI(200)
C
      COMMON/STORE/ NSTORE,JSTORE(20),ZTOP(20),ASTORE(20)
C
      REAL LEN
C
      COMMON/TRNSFR/ NFREE,JFREE(25),NTIDE,JTIDE(25),NGATE,JGATE(25),
     1 NWEIR,JWEIR(60,2),NORIF,JORIF(60,2),NPUMP,JPUMP(60,2)
C
      COMMON/OUT/ NPRT,IPRT,NHPRT,JPRT(20),PRTH(100,20),PRGEL(20),
     1 NQPRT,CPRT(20),PRTV(100,20),PRTQ(100,20),IDUM(12),ICOL(10),
     2 LTIME,NPLT,JPLT(20),YPLT(102,20),LPLT,KPLT(20),QPLT(102,20),
     3 TPLT(102),NPTOT,NSTART,INTER,PRTY(100,20)
      COMMON/STATS/VMAXX(187),QMAXX(187),DEPMAX(187),IVHR(187),
     2IVMIN(187),IQHR(187),IQMIN(187),IDHR(187),IDMIN(187),SURLEN(187),
     3SUMQIN,VLEFT
      INTEGER CPRT
      DIMENSION ICHECK(187),JCHECK(187),IND(2)
      DATA IND/1H ,1H*/
C
C
C                            E X E C U T I O N
C
      COUNT=0.0
      NDIM=187
      DO 5 N=1,NDIM
      ICHECK(N)=IND(1)
      DO 5 M=1,8
    5 NCHAN(N,M)=0
C
C******** INPUT DATA
      CALL INDATA
C
C******** INITIALIZATION
      ICYC=0
```

```
      LTIME=0
      NPTOT=0
      NERROR=0
      TIME=TZERO
      DO 901 N=1,NC
      VMAXX(N)=0.0
      QMAXX(N)=0.0
      IVHR(N)=0
      IVMIN(N)=0
      IQHR(N)=0
      IQMIN(N)=0
  901 CONTINUE
      SUMQIN = 0.
      VLEFT = 0.
      DO 911 J=1,NJ
      SURLEN(J)=0.0
      DEPMAX(J)=0.0
      IDHR(J)=0
      IDMIN(J)=0
      QOU(J) = 0.
  911 CONTINUE
C
C ****** INITIALIZATION FOR DRY WEATHER FLOWS
C       IS NOW DONE IN INDATA (BEFORE READING INFLOW HYDROGRAPHS)
C
C
      DO 20 N=1,NTL
      QT(N)=Q(N)
      AT(N)=0.
      IF(N.GT.NTC.OR.QT(N).EQ.0.) GO TO 20
      NL=NJUNC(N,1)
      NH=NJUNC(N,2)
      HNL=Y(NL)+Z(NL)
      HNH=Y(NH)+Z(NH)
      CALL HEAD(N,NL,NH,HNL,HNH,QT(N),AT(N),VT(N),HRAD,ANL,ANH,RNL,TZERO
     .,1)

   20 CONTINUE
      DO 30 J=1,NJ
      YT(J)=Y(J)
   30 CONTINUE
C
C******** MAJOR PROGRAM LOOP THROUGH TIME
      MP=(NTCYC+99)/100
      DO 760 MCY=1,NTCYC,MP
      NPTOT=NPTOT+1
      DO 640 MCYY=1,MP
      TIME=TIME+DELT
      TIME2=TIME-DELT2
      ICYC=ICYC+1
C
C******** SELECT INPUT HYDROGRAPHS
      CALL INFLOW
C
C******** STORE OLD FLOW VALUES
      DO 60 N=1,NTL
```

```
   60 QO(N)=Q(N)
C
C******** INITIALIZE CONTINUITY PARAMETERS
      DO 80 J=1,NJ
      AS(J)=0.
      SUMQ(J)=QIN(J)
      SUMQS(J)=QIN(J)
   80 SUMAL(J)=0.
C
C******** FULL-STEP AREA, RADIUS : VELOCITY
C******** HALF-STEP FLOW
      COUNT=COUNT+.5
      DO 120 N=1,NTC
      NL=NJUNC(N,1)
      NH=NJUNC(N,2)
      H(N,1)=Y(NL)+Z(NL)
      H(N,2)=Y(NH)+Z(NH)
      CALL HEAD(N,NL,NH,H(N,1),H(N,2),Q(N),A(N),V(N),HRAD,ANH,ANL,RNL,
     1TIME,ICYC)

      DELQ4=+DELT2*V(N)**2*(ANH-ANL)/LEN(N)
      DELQ3=2.*V(N)*(A(N)-AT(N))
      DELQ2=-(DELT2*32.2*(H(N,2)-H(N,1))/LEN(N))*A(N)
      QNEW=QO(N)+DELQ2+DELQ3+DELQ4
      AKON=-DELT2*(ROUGH(N)/HRAD**1.33333)*ABS(V(N))
      DELQ1=AKON*QNEW/(1.-AKON)
      QT(N)=QNEW+DELQ1
C******** CHECK FOR NORMAL FLOW
      IF(H(N,1) .GT. ZCROWN(NL)) GO TO 101
      DELH=H(N,1)-H(N,2)
      DELZP=ZP(N,1)-ZP(N,2)
      IF(QT(N).LE.0.) GO TO 101
      IF(DELH-DELZP) 100,101,101
  100 QNORM=SQRT(32.2*(ZP(N,1)-ZP(N,2))/(LEN(N)*ROUGH(N)))
     1 *ANL*RNL**0.6667
      IF(QNORM.GT.QT(N)) GO TO 101
      QT(N)=QNORM
C******** COMPUTE CONTINUITY PARAMETERS
  101 DQDH=1./(1.-AKON)*32.2*DELT2*A(N)/LEN(N)
      SUMQ(NL)=SUMQ(NL)-0.5*(QT(N)+QO(N))
      SUMQS(NL)=SUMQS(NL)-QT(N)
      SUMAL(NL)=SUMAL(NL)+DQDH
      SUMQ(NH)=SUMQ(NH)+0.5*(QT(N)+QO(N))
      SUMQS(NH)=SUMQS(NH)+QT(N)
      SUMAL(NH)=SUMAL(NH)+DQDH
  120 CONTINUE
C
C******** SET HALF STEP OUTFLOWS AND INTERNAL TRANSFERS
      CALL BOUND(Y,YT,QT,TIME2,DELT2)
      N1=NTC+1
      DO 130 N=N1,NTL
      NL=NJUNC(N,1)
      SUMQ(NL)=SUMQ(NL)-0.5*(QT(N)+QO(N))
      SUMQS(NL)=SUMQS(NL)-QT(N)
      NH=NJUNC(N,2)
      IF(NH.EQ.0)GO TO 130
```

```
      SUMQ(NH)=SUMQ(NH)+0.5*(QT(N)+QO(N))
      SUMQS(NH)=SUMQS(NH)+QT(N)
  130 CONTINUE
C
C******** HALF-STEP HEAD
      DO 320 J=1,NJ
      IF(JSKIP(J)) 140,140,300
  140 IF(AS(J).GT.0.0 .OR. Y(J).GE.(ZCROWN(J)-Z(J))) GO TO 135
      IF(NERROR.LE.10) WRITE(N6,2400) ICYC,JUN(J)
 2400 FORMAT(' ***** WARNING ***** ICYC=',I5,'  ZERO SURFACE AREA COMPUT
     .ED AT JUNCTION',I6,'  CHECK INPUT DATA FOR HIGH PIPE ')
      NERROR=NERROR+1
      YT(J)=0.0
      GO TO 300
  135 CONTINUE
      YCROWN=0.96*(ZCROWN(J)-Z(J))
      IF(Y(J)-YCROWN) 240,240,260
C
C******** COMPUTE YT FOR FREE SURFACE JUNCTIONS
  240 YT(J)=Y(J)+SUMQ(J)*DELT2/AS(J)
      IF(YT(J).LT.0.) YT(J)=0.
C****** WHEN JUNCTION SURCHARGES, 'ASFULL' WILL BE THE LAST
C        VALUE OF 'AS' UNDER FREE SURFACE FLOW
      ASFULL(J) = AS(J)
      GO TO 300
C
C******** ADJUST HEAD AT SURCHARGED JUNCTIONS
C........APPLY 1/2 OF COMPUTED CORRECTION
  260 DENOM=SUMAL(J)
      IF(Y(J).LT.2.*YCROWN) DENOM=SUMAL(J)+(ASFULL(J)/DELT2-SUMAL(J))
     .        *EXP(-15.*(Y(J)-YCROWN)/YCROWN)
      YT(J)=Y(J)+0.50*SUMQS(J)/DENOM
      IF((YT(J)+Z(J)).GT.GRELEV(J)) YT(J)=GRELEV(J)-Z(J)
      IF(YT(J).LT.YCROWN) YT(J)=YCROWN-0.001
C
C******** INITIALIZE FOR FULL STEP FLOWS
  300 AS(J)=0.
      SUMQ(J)=QIN(J)
      SUMQS(J)=QIN(J)
      SUMAL(J)=0.
  320 CONTINUE
C     WRITE(N6,321) COUNT,(YT(J),J=1,NJ),(QT(N),N=1,NTC)
  321 FORMAT(6X,F6.1,2X,5F11.4,4F12.4)
C
C******** HALF-STEP AREA, RADIUS : VELOCITY
C******** FULL-STEP FLOW
      COUNT=COUNT+.5
      DO 360 N=1,NTC
      NL=NJUNC(N,1)
      NH=NJUNC(N,2)
      H(N,1)=YT(NL)+Z(NL)
      H(N,2)=YT(NH)+Z(NH)
      CALL HEAD(N,NL,NH,H(N,1),H(N,2),QT(N),AT(N),VT(N),HRAD,ANH,ANL,
     1RNL,TIME,ICYC)

      DELQ4=+DELT*VT(N)**2*(ANH-ANL)/LEN(N)
```

```
      DELQ3=4.*VT(N)*(AT(N)-A(N))
      DELQ2=-(DELT*32.2*(H(N,2)-H(N,1))/LEN(N))*AT(N)
      QNEW=QO(N)+DELQ2+DELQ3+DELQ4
      AKON=-DELT*(ROUGH(N)/HRAD**1.33333)*ABS(VT(N))
      DELQ1=AKON*QNEW/(1.-AKON)
      Q(N)=QNEW+DELQ1
C******** DO NOT ALLOW A FLOW REVERSAL IN ONE TIME STEP
      DIRQT=SIGN(1.,QT(N))
      DIRQ=SIGN(1.,Q(N))
      IF(DIRQT/DIRQ.LT.0.) Q(N)=0.001*DIRQ
C******** CHECK FOR NORMAL FLOW
      IF(H(N,1) .GT. ZCROWN(NL)) GO TO 341
      ICHECK(N)=IND(1)
      DELH=H(N,1)-H(N,2)
      DELZP=ZP(N,1)-ZP(N,2)
      IF(Q(N).LE.0.) GO TO 341
      IF(DELH-DELZP) 340,341,341
  340 QNORM=SQRT(32.2*(ZP(N,1)-ZP(N,2))/(LEN(N)*ROUGH(N)))
     1 *ANL*RNL**0.6667
      IF(QNORM.GT.Q(N)) GO TO 341
      ICHECK(N)=IND(2)
      Q(N)=QNORM
C******** COMPUTE CONTINUITY PARAMETERS
  341 DQDH=1./(1.-AKON)*32.2*DELT*AT(N)/LEN(N)
      SUMQ(NL)=SUMQ(NL)-0.5*(Q(N)+QO(N))
      SUMQS(NL)=SUMQS(NL)-Q(N)
      SUMAL(NL)=SUMAL(NL)+DQDH
      SUMQ(NH)=SUMQ(NH)+0.5*(Q(N)+QO(N))
      SUMQS(NH)=SUMQS(NH)+Q(N)
```

```
      SUMAL(NH)=SUMAL(NH)+DQDH
  360 CONTINUE
C
C******** SET FULL STEP OUTFLOWS AND INTERNAL TRANSFERS
      CALL BOUND(YT,Y,Q,TIME,DELT)
      N1=NTC+1
      DO 370 N=N1,NTL
C******** DO NOT ALLOW FLOW REVERSAL IN ONE TIME STEP
      DIRQT=SIGN(1.,QT(N))
      DIRQ=SIGN(1.,Q(N))
      IF(DIRQT/DIRQ .LT. 0.) Q(N)=0.001*DIRQ
      NL=NJUNC(N,1)
      SUMQ(NL)=SUMQ(NL)-0.5*(Q(N)+QO(N))
      SUMQS(NL)=SUMQS(NL)-Q(N)
      NH=NJUNC(N,2)
      IF(NH.EQ.0)GO TO 370
      SUMQ(NH)=SUMQ(NH)+0.5*(Q(N)+QO(N))
      SUMQS(NH)=SUMQS(NH)+Q(N)
  370 CONTINUE
C
C******** FULL-STEP HEAD
      DO 560 J=1,NJ
      IF(JSKIP(J)) 380,380,560
  380 IF(AS(J).GT.0.0 .OR. YT(J).GE.(ZCROWN(J)-Z(J))) GO TO 375
      IF(NERROR.LE.10) WRITE(N6,2400) ICYC,JUN(J)
      NERROR=NERROR+1
      Y(J)=0.0
      GO TO 560
  375 CONTINUE
      YCROWN=0.96*(ZCROWN(J)-Z(J))
      IF(YT(J)-YCROWN) 480,480,500
C
```

```
C******** COMPUTE Y FOR FREE SURFACE JUNCTIONS
  480 Y(J)=Y(J)+SUMQ(J)*DELT/AS(J)
      JCHECK(J)=IND(1)
      IF(Y(J).LT.0.) Y(J)=0.
C******** AT INCIPIENT SURCHARGE, 'AS(J)' WILL BE THE ACTUAL
C            VALUE OF 'ASFULL'
      ASFULL(J) = AS(J)
      GO TO 560
C
C******** ADJUST HEAD AT SURCHARGED JUNCTIONS
C........APPLY 1/2 OF COMPUTED CORRECTION
  500 DENOM=SUMAL(J)
      IF(YT(J).LT.2.*YCROWN) DENOM=SUMAL(J)+(ASFULL(J)/DELT2-SUMAL(J))
     .      *EXP(-15.*(YT(J)-YCROWN)/YCROWN)
      Y(J)=YT(J)+1.0*SUMQS(J)/DENOM
      IF((Y(J)+Z(J)).GT.GRELEV(J)) Y(J)=GRELEV(J)-Z(J)
      IF(Y(J).LT.YCROWN) Y(J)=YCROWN-0.001
      JCHECK(J)=IND(2)
  560 CONTINUE
C
C******** COMPUTE CONTINUITY PARAMETERS
C
      DO 950 J=1,NJ
      SUMQIN = SUMQIN + QIN(J)*DELT
      IF(Y(J).EQ.GRELEV(J)-Z(J)) QOU(J)=QOU(J)+SUMQS(J)*DELT
  950 CONTINUE
      NL = NTC + 1
C******** SYSTEM OUTFLOWS
      DO 960 N=NL,NTL
      J=NJUNC(N,1)
      IF(NJUNC(N,2).EQ.0) QOU(J)=QOU(J)+Q(N)*DELT
  960 CONTINUE
C
C******** WRITE HYDRAULIC DATA FOR INPUT TO QUALITY TRANSPORT MODEL
      IF(N22 .GT. 0) WRITE(N22) TIME,(Q(N), N=1,NTC),(Y(J), J=1,NJ)
C
C********  CHECK FOR MAXIMUM FLOW AND VELOCITY IN CONDUITS
      NHOUR=TIME/3600.
      TMIN=(TIME-NHOUR*3600.)/60.
      DO 902 N=1,NC
      IF(Q(N).GT.QMAXX(N)) GO TO 903
      GO TO 904
  903 QMAXX(N)=Q(N)
      IQHR(N)=NHOUR
      IQMIN(N)=TMIN+0.5
  904 IF(V(N).GT.VMAXX(N)) GO TO 905

      GO TO 902
  905 VMAXX(N)=V(N)
      IVHR(N)=NHOUR
      IVMIN(N)=TMIN+0.5
  902 CONTINUE
C
C********  CHECK FOR SURCHARGE AND MAXIMUM DEPTH AT JUNCTIONS
      DO 906 J=1,NJ
      IF((Z(J)+Y(J)).GT.ZCROWN(J)) SURLEN(J)=SURLEN(J)+DELT/60.0
```

```
      IF(Y(J).GT.DEPMAX(J)) GO TO 907
      GO TO 906
  907 DEPMAX(J)=Y(J)
      IDHR(J)=NHOUR
      IDMIN(J)=TMIN+0.5
  906 CONTINUE
C
C******** CHECK PRINTOUT REQUIREMENTS
C.... INTERMEDIATE PRINTOUT
      IF(MOD(ICYC,INTER).NE.0) GO TO 570
      WRITE(N6,1504)
      WRITE(N6,1500)ICYC,NHOUR,TMIN
 1500 FORMAT(1X,'CYCLE ',I5,6X,'TIME ',I4,' HRS - ',F5.2,' MIN',//)
      WRITE(N6,1501)
 1501 FORMAT(1X,'JUNCTIONS / DEPTHS ',/)
      WRITE(N6,1502)((JUN(J),Y(J)),J=1,NJ)
 1502 FORMAT(3X,I5,'/',F7.2,7(3X,I5,'/',F7.2)/)
      WRITE(N6,1503)
 1503 FORMAT(/,1X,'CONDUITS / FLOWS ',/)
      WRITE(N6,1502)((NCOND(N),Q(N)),N=1,NTL)
 1504 FORMAT(/,64(2H- ),//)
  570 CONTINUE
      IF(ICYC-NSTART) 640,580,580
  580 NSTART=NSTART+INTER
      LTIME=LTIME+1
C******** STORE HGL FOR PRINTOUT
      DO 600 I=1,NHPRT
      J=JPRT(I)
      YMAX=ZCROWN(J)-Z(J)
      PRTY(LTIME,I)=AMIN1(Y(J),YMAX)
  600 PRTH(LTIME,I)=Y(J)+Z(J)
C******** STORE FLOW * VELOCITY FOR PRINTOUT
      DO 620 I=1,NQPRT
      L=CPRT(I)
      NL=NJUNC(L,1)
      NH=NJUNC(L,2)
      PRTQ(LTIME,I)=Q(L)
  620 PRTV(LTIME,I)=V(L)
  640 CONTINUE
C
C******** STORE HGL * FLOW FOR PRINTER PLOT ROUTINE
      TPLT(NPTOT)=TIME/3600.
      IF(NPLT) 700,700,660
  660 DO 680 N=1,NPLT
      J=JPLT(N)
  680 YPLT(NPTOT,N)=Y(J)+Z(J)
  700 IF(LPLT) 760,760,720
  720 DO 740 N=1,LPLT
      L=KPLT(N)
  740 QPLT(NPTOT,N)=Q(L)
  760 CONTINUE
C******** COMPUTE WATER VOLUME LEFT IN STORAGE
      IF(NSTORE.EQ.0) GO TO 801
```

```
      DO 800 I=1,NSTORE
      J=JSTORE(I)
  800 VLEFT=VLEFT+Y(J)*ASTORE(J)
  801 CONTINUE
      DO 810 N=1,NC
      NL = NJUNC(N,1)
      NH = NJUNC(N,2)
      H1 = Y(NL) + Z(NL)
      H2 = Y(NH) + Z(NH)
      CALL HEAD(N,NL,NH,H1,H2,Q(N),A(N),V(N),HRAD,ANH,ANL,
     *RNL,TIME,ICYC)

      VLEFT = VLEFT + 0.5*(ANH + ANL)*LEN(N)
  810 CONTINUE
C
C******** PRINT * PLOT OUTPUT
      CALL OUTPUT
      STOP

      END
```

```
      BLOCK DATA
C
      COMMON /BD/ANORM(26,5),HRNORM(26,5),TWNORM(26,5)
      COMMON/LAB/ TITLE(40),XLAB(11),YLAB(6),HORIZ(5),VERT(6)
C$$$$$COMMON /LAB/ TITL(18),XLAB(11),YLAB(6),HORIZ2(20),VERT2(7,6),
C$$$$*IT,IJ,TITLE(40),HORIZ(5),VERT(6)
C
C******** NORMALIZED CROSS-SECTIONAL AREA
      DATA ANORM/
     1 .0000,.0134,.0374,.0680,.1033,.1423,.1845,.2292,.2759,.3242,
     2 .3736,.4237,.4745,.5255,.5763,.6264,.6758,.7241,.7708,.8154,
     3 .8576,.8967,.9320,.9626,.9866,1.000,
     4 .0000,.0400,.0800,.1200,.1600,.2000,.2400,.2800,.3200,.3600,
     5 .4000,.4400,.4800,.5200,.5600,.6000,.6400,.6800,.7200,.7600,
     6 .8000,.8400,.8800,.9200,.9600,1.000,
     7 .0000,.0181,.0508,.0908,.1326,.1757,.2201,.2655,.3118,.3587,
     8 .4064,.4542,.5023,.5506,.5987,.6462,.6931,.7387,.7829,.8253,
     9 .8652,.9022,.9356,.9645,.9873,1.000,
     1 .0000,.0150,.0400,.0550,.0850,.1200,.1555,.1900,.2250,.2750,
     2 .3200,.3700,.4200,.4700,.5150,.5700,.6200,.6800,.7300,.7800,
     3 .8350,.8850,.9250,.9550,.9800,1.000,
     4 .0000,.0173,.0457,.0828,.1271,.1765,.2270,.2775,.3280,.3780,
     5 .4270,.4765,.5260,.5740,.6220,.6690,.7160,.7610,.8030,.8390,
     6 .8770,.9110,.9410,.9680,.9880,1.000/
C
C******** NORMALIZED HYDRAULIC RADIUS
C******** SECOND SHAPE IS RECTANGULAR - BUT DO NOT USE - CANNOT NORMALIZ
C         A GENERAL RECTANGULAR HYDRAULIC RADIUS
      DATA HRNORM/
     1 .0100,.1048,.2052,.3016,.3944,.4824,.5664,.6456,.7204,.7912,
     2 .8568,.9176,.9736,1.024,1.070,1.110,1.144,1.174,1.194,1.210,
     3 1.217,1.215,1.203,1.178,1.132,1.000,
     4 .0000,.0400,.0800,.1200,.1600,.2000,.2400,.2800,.3200,.3600,
     5 .4000,.4400,.4800,.5200,.5600,.6000,.6400,.6800,.7200,.7600,
     6 .8000,.8400,.8800,.9200,.9600,1.000,
     7 .0100,.1040,.2065,.3243,.4322,.5284,.6147,.6927,.7636,.8268,
     8 .8873,.9417,.9905,1.036,1.077,1.113,1.143,1.169,1.189,1.202,
     9 1.208,1.206,1.195,1.170,1.126,1.000,
     1 .0100,.0970,.2160,.3020,.3860,.4650,.5360,.6110,.6760,.7350,
     2 .7910,.8540,.9040,.9410,1.008,1.045,1.076,1.115,1.146,1.162,
     3 1.186,1.193,1.186,1.162,1.107,1.000,
     4 .0100,.0952,.1890,.2730,.3690,.4630,.5600,.6530,.7430,.8220,
     5 .8830,.9490,.9990,1.055,1.095,1.141,1.161,1.188,1.206,1.206,
     6 1.206,1.205,1.196,1.168,1.127,1.000/
C
C******** NORMALIZED SURFACE WIDTH
      DATA TWNORM/
     1 .3919,.3919,.5426,.6499,.7332,.8000,.8542,.8980,.9330,.9600,
     2 .9798,.9928,.9992,.9992,.9928,.9798,.9600,.9330,.8980,.8542,
     3 .8000,.7332,.6499,.5426,.3919,.3919,
     4 1.000,1.000,1.000,1.000,1.000,1.000,1.000,1.000,1.000,1.000,
     5 1.000,1.000,1.000,1.000,1.000,1.000,1.000,1.000,1.000,1.000,
     6 1.000,1.000,1.000,1.000,1.000,1.000,
     7 .5878,.5878,.8772,.8900,.9028,.9156,.9284,.9412,.9540,.9668,
     8 .9798,.9928,.9992,.9992,.9928,.9798,.9600,.9330,.8980,.8542,
     9 .8000,.7332,.6499,.5426,.3919,.3919,
```

```
         1 .2980,.2980,.4330,.5080,.5820,.6420,.6960,.7460,.7910,.8360,
         2 .8660,.8960,.9260,.9560,.9700,.9850,1.000,.9850,.9700,.9400,
         3 .8960,.8360,.7640,.6420,.3100,.3100,
         4 .4900,.4900,.6670,.8200,.9300,1.000,1.000,1.000,.9970,.9940,
         5 .9880,.9820,.9670,.9480,.9280,.9040,.8740,.8420,.7980,.7500,
         6 .6970,.6370,.5670,.4670,.3420,.3420/
C
          DATA  VERT          /4HJUNC,4HTION,4HWATR,4H SUR,4HELEV,4H(FT)/
C
C$$$$$DATA  VERT2          /'  FL','OW  ','   I','N   ','    ','CFS ',
C$$$$$* 36*4H    /
C
          DATA  TITLE          /4H THE,4HRE I,4HS NO,4H WAT,4HERSH,4HED I,
         1 4HNPUT,4H SO ,4HTHE ,4HPLOT,4HS AR,4HE FO,4HR CA,4HRD H,4HYETO,
         2 4HGRAP,4HHS, ,4HOR F,4HOR  ,4H    ,4H CON,4HSTAN,4HT IN,4HFLOW,
         3 16*4H    /
C
          DATA HORIZ/4HCLOC,4HK TI,4HME (,4HHOUR,4HS)  /
C
C$$$$$DATA  TITL           /15*'    ','JUNC','TION',' NO.'/
C
C$$$$$DATA  HORIZ          /4HCLOC,4HK TI,4HME (,4HHOUR,4HS   ,8*4H    /
C
C$$$$$DATA  HORIZ2         /8*4H    ,4HTIME,4H IN ,4HHOUR,4HS   ,8*4H    /
C
          END
```

1. Compute current elevation of receiving water backwater. Depending on the tidal index, the backwater condition will be constant, tidal or below the system outfalls. The tidally varied backwater condition is computed by a Fourier series about a mean time equal to the first coefficient, A1.

2. Compute depth at orifice junction for sump orifice flowing less than full.

3. Compute discharge over transverse and sideflow weirs. Check for reverse flow, surcharge, and weir submergence. If weir is surcharged, compute flow by orifice-type equation. If weir is submerged, compute the submergence coefficient and re-compute weir flow. If a tide gate is present at weir node, then compute head loss, reduce driving head on weir and re-compute weir discharge.

4. Compute pump discharges based on current junction or wet-well level and corresponding pump rate. If wet-well is flooded, set pump rate at maximum level and reduce inflow.

Subroutine DEPTH

Subroutine DEPTH computes the critical and normal depths corresponding to a given discharge using the critical flow and Manning uniform flow equations, respectively. Tables of normalized values for the cross-sectional area, hydraulic radius and surface width of each pipe class are taken from a Block Data element to speed the computations of critical and normal depth. Subroutine DEPTH is used by subroutines BOUND and HEAD and is listed below.

```
      SUBROUTINE BOUND(YDEP,YDEPT,QP,T,DT)
C
C                 THIS SUBROUTINE COMPUTES THE LINK FLOW 'QP(LINK)' FOR
C                 EACH EXTERNAL * INTERNAL NODE TO NODE TRANSFER
C
      COMMON /BD/ANORM(26,5),HRNORM(26,5),TWNORM(26,5)
      COMMON/TRAP/STHETA(200),SPHI(200)
      COMMON/FILES/ N5,N6,N21,N22,NPOLL
      COMMON/CONTR/ NTCYC,DELTQ,DELT,DELT2,TZERO,ALPHA(30),
     1 NJ,NC,NTC,NTL,ICYC,NJSW,MJSW,TIME,TIME2,A1,A2,A3,A4,A5,A6,A7,W
C
      COMMON/JUNC/Y(187),YT(187),NCHAN(187,8),AS(187),Z(187),QIN(187),
     1 QOU(187),QINST(187),GRELEV(187),JUN(187),ZCROWN(187),JSKIP(187)
     2 ,SUMAL(187),SUMQ(187),SUMQS(187),ASFULL(187)
C
      COMMON/PIPE/LEN(187),NJUNC(187,2),AFULL(187),AT(187),
     1 Q(187),V(187),VT(187),DEEP(187),A(187),WIDE(187),RFULL(187),
     2 NKLASS(187),ZP(187,2),QT(187),QO(187),H(187,2),NCOND(187),
     3 ROUGH(187)
      REAL LEN
C
      DIMENSION YDEP(187),YDEPT(187),QP(187)
C
      COMMON/STORE/ NSTORE,JSTORE(20),ZTOP(20),ASTORE(20)
      COMMON/ORF/ NORIF,LORIF(60),AORIF(60),CORIF(60)
      COMMON/WEIR/ NWEIR,LWEIR(60),KWEIR(60),YTOP(60),YCREST(60),
     2 WLEN(60),COEF(60),COEFS(60)
      COMMON/PUMP/ NPUMP,LPUMP(20),PRATE(20,3),VRATE(20,3),VWELL(20),
     1 JPFUL(20),IPTYP(20)
      COMMON/BND/ NFREE,JFREE(25),NTIDE,JTIDE(25),NGATE,JGATE(25)
C
C                           E X E C U T I O N
      HTIDE=-9999.
C
C
C******** COMPUTE NEW ELEVATION OF TIDE
      GO TO (110,109,108,108), NTIDE
  108 HTIDE=A1+A2*SIN(W*T)+A3*SIN(2.*W*T)+A4*SIN(3.*W*T)
     1        +A5*COS(W*T)+A6*COS(2.*W*T)+A7*COS(3.*W*T)
      IF(MOD(ICYC,30).EQ.0) WRITE(N6,1234) ICYC,HTIDE
 1234 FORMAT(' CYCLE',I5,'  HTIDE=',F10.2)
      GO TO 110
  109 HTIDE=A1
  110 CONTINUE
C
C******** ASSIGN SURFACE AREA TO STORAGE JUNCTIONS
C
      IF (NSTORE) 116,116,112
  112 DO 114 I=1,NSTORE
      J = JSTORE(I)
      AS(J) = AS(J) + ASTORE(I)
  114 CONTINUE
  116 CONTINUE
C
C******** COMPUTE HEAD AT JUNCTIONS WITH SUMP ORIFICES WHERE
C         DEPTH IS BELOW JUNCTION INVERT
```

```
      IF(NORIF)200,200,120
  120 DO 180  I=1,NORIF
      LINK=LORIF(I)
      J1=NJUNC(LINK,1)
      JSKIP(J1)=0
      IF(NKLASS(LINK) .EQ. 7 .OR. YDEP(J1) .GT. 0.) GO TO 180
      JSKIP(J1)=1
      YNL=0.96*DEEP(LINK)+YDEP(J1)
      CALL HYDRAD(LINK,NKLASS(LINK),YNL,RNL,ANL,BNL)
      YDEPT(J1)=Y(J1)+SUMQ(J1)*DT/(BNL*LEN(LINK)/2.)
      IF(YDEPT(J1).GT.0.) YDEPT(J1)=0.001
  180 CONTINUE
C
C******** COMPUTE DISCHARGE OVER TRANSVERSE AND SIDEFLOW WEIRS
  200 IF(NWEIR) 580,580,220
  220 DO 560 I=1,NWEIR
C**** INITIALIZE
      WK=COEF(I)
      POWER=1.5
      V2=0.0
      LINK=LWEIR(I)
      DIR=+1.
      J1=NJUNC(LINK,1)
      J2=NJUNC(LINK,2)
      Y1=YDEP(J1)
      IF(J2) 240,240,260
  240 Y2=AMAX1((HTIDE-Z(J1)),YCREST(I))
      HEADW=Y1-YCREST(I)
      IF(HEADW) 480,480,320
  260 Y2=YDEP(J2)
      HEADW=AMAX1(Y1,Y2)-YCREST(I)
      IF(HEADW) 480,480,280
C**** CHECK FOR BACKFLOW
  280 IF(Y1-Y2) 300,320,320
  300 DIR=-1.
      Y1=Y2
      Y2=YDEP(J1)
      J1=J2
      J2=NJUNC(LINK,1)
C**** CHECK FOR SURCHARGE
  320 IF(Y1.GT.YTOP(I)) GO TO 440
      IF(DIR) 380,340,340
  340 IF(KWEIR(I)-3) 380,360,360
C**** WK IS A FUNCTION OF APPROACH VELOCITY FOR SIDEFLOW WEIRS
  360 WK=COEF(I)
      V2=0.0
      POWER=1.67
C**** WEIR DISCHARGE
  380 QWEIR=WK*WLEN(I)*((HEADW+V2/64.4)**POWER-(V2/64.4)**POWER)
      KW=KWEIR(I)
      GO TO (420,400,420,400) KW
C**** APPLY ARMCO TIDE GATE CORRECTION
C**** (ARMCO WATER CONTROL GATES CATALOG)
  400 IF(HTIDE.GE.(YDEP(J1)+Z(J1))) GO TO 480
      VEL1=COEF(I)*HEADW**(POWER-1.)
      HLOSS=(4./32.2)*VEL1**2*EXP(-1.15*VEL1/SQRT(YTOP(I)-YCREST(I)))
```

```
      HEADW=HEADW-HLOSS
      IF(HEADW.LE.0) GO TO 480
      IF((YCREST(I)+Z(J)+HEADW).LE.HTIDE) GO TO 480
      QWEIR=COEF(I)*WLEN(I)*HEADW**POWER
C
C********* SUBMERGED WEIR COMPUTATIONS, DFK, 8/74
C
  420 RATIO=(Y2-YCREST(I))/(Y1-YCREST(I))
      IF((Y2-YCREST(I)).LE.0) GO TO 500
      IF(RATIO.LE.0.3) GO TO 421
      IF(RATIO.LE.0.75) GO TO 422
      IF(RATIO.LE.0.85) GO TO 423
      IF(RATIO.LE.0.95) GO TO 424
      CONST=0.4-0.3*(RATIO-0.95)/0.05
      GO TO 430
  421 CONST=1.
      GO TO 430
  422 CONST=1.0-0.1*(RATIO-0.3)/0.45
      GO TO 430
  423 CONST=0.9-0.1*(RATIO-0.75)/0.1
      GO TO 430
  424 CONST=0.8-0.4*(RATIO-0.85)/0.1
  430 QWEIR=CONST*COEF(I)*WLEN(I)*(Y1-YCREST(I))**1.5
      GO TO 500
C**** OUTFLOW IN SURCHARGED CONDITION
  440 IF(Y1-Y2) 480,480,460
  460 HEADW=Y1-AMAX1(Y2,YCREST(I))
      IF(COEFS(I).GT.0.0) GO TO 470
      ARE=(YTOP(I)-YCREST(I))*WLEN(I)
      COEFS(I)=ABS(QP(LINK))/(ARE*SQRT(64.4*HEADW+V2))
  470 QWEIR=COEFS(I)*WLEN(I)*(YTOP(I)-YCREST(I))*SQRT(64.4*HEADW+V2)
      GO TO 500
  480 QWEIR=0.
  500 QP(LINK)=DIR*QWEIR
  560 CONTINUE
C
C******** COMPUTE PUMP DISCHARGES
C
C******** NOTE -- ONLY ONE INFLUENT PIPE CAN BE CONNECTED TO A PUMP NODE
C
  580 IF(NPUMP)  920,920,600
  600 DO 900  I=1,NPUMP
      LINK=LPUMP(I)
      J1=NJUNC(LINK,1)
      J2=NJUNC(LINK,2)
C******** COMPUTE INFLOW TO WET WELL FOR GATES OPEN CONDITION
      N=NCHAN(J1,1)
      QINJ=QP(N)
      IF(NJUNC(N,2).NE.J1) QINJ=-QP(N)
      IF(QINJ.LT.0.) QINJ=0.
      CALL DEPTH(N,NKLASS(N),QP(N),YCRIT,YNORM,TIME,ICYC)
      GO TO (710,885) IPTYP(I)
C****** SET CRITICAL DEPTH AT WET WELL FOR OFF-LINE PUMP
  710 YDEPT(J1)=AMIN1(YCRIT,YNORM)
      VWELL(I)=VWELL(I)+QINJ*DELT2
C******** SET PUMP RATE
```

```
  720 QOUT=0.0
      IF(VWELL(I)) 800,800,740
  740 QOUT=PRATE(I,1)
      IF(VWELL(I)-VRATE(I,1)) 800,760,760
  760 QOUT=PRATE(I,2)
      IF(VWELL(I)-VRATE(I,2)) 800,780,780
  780 QOUT=PRATE(I,3)
C******** COMPUTE NEW WET WELL VOLUME
  800 VNEW=VWELL(I)-QOUT*DELT2
C******** CHECK FOR DRY WELL
      IF(VNEW) 820,820,840
  820 QOUT=VWELL(I)/DELT2
      VWELL(I)=0.0
      QP(LINK)=QOUT
      JPFUL(I)=1
      GO TO 900
C******** CHECK FOR FLOODED WELL
  840 IF(VRATE(I,3)-VNEW) 860,860,880
  860 DIFF=VNEW-VRATE(I,3)
      VWELL(I)=VRATE(I,3)
      QOUT=PRATE(I,3)
      QP(LINK)=QOUT
      N=NCHAN(J1,1)
C....THROTTLE PUMP STATION INFLOW
      QP(N)=QP(N)-DIFF/DELT2
      GO TO 900
C******** NORMAL WET WELL CONDITION
  880 VWELL(I)=VNEW
      QP(LINK)=QOUT
C
C****** SET PUMP RATE FOR IN-LINE PUMP
  885 IF(QINJ.GT.PRATE(I,1)) GO TO 886
      YCNTRL = AMIN1(YCRIT,YNORM)
      IF(YDEP(J1).GT.YCNTRL) GO TO 886
C****** THROTTLE PUMP STATION PUMP RATE
      YDEPT(J1) = YCNTRL
      JSKIP(J1) = 1
      QOUT = QINJ
      GO TO 888
C****** SET PUMP RATE
  886 JSKIP(J1) = 0
      QOUT = PRATE(I,1)
      IF(YDEP(J1).GT.VRATE(I,1)) QOUT = PRATE(I,2)
      IF(YDEP(J2).GT.VRATE(I,2)) QOUT = PRATE(I,3)
  888 QP(LINK) = QOUT
  900 CONTINUE
C
C******** SET DEPTH AT FREE OUTFALL * TIDAL NODES (ONE PIPE/NODE)
  920 IF(NFREE) 980,980,940
  940 DO 960 I=1,NFREE
      J=JFREE(I)
      N=NCHAN(J,1)
      LINK=NCHAN(J,2)
      QP(LINK)=QP(N)
C.... CHECK FOR OUTFALL PIPE ON AN ADVERSE SLOPE
      IF(NJUNC(N,1).EQ.J)QP(LINK)=-QP(LINK)
```

```
      CALL DEPTH(N,NKLASS(N),QP(N),YCRIT,YNORM,TIME,ICYC)
      YDEPT(J)=AMIN1(YCRIT,YNORM)
C******** CHECK FOR FULL PIPE OR SURCHARGE
      IF(YDEPT(J).GT.DEEP(N)) YDEPT(J)=DEEP(N)
C******** CHECK FOR TIDAL INFLUENCE
      IF((YDEPT(J)+Z(J)).LT.HTIDE) YDEPT(J)=HTIDE-Z(J)
  960 CONTINUE
C
C******** SET DEPTH AT TIDE GATE OR CLOSE GATE
  980 IF(NGATE) 1080,1080,1000
 1000 DO 1060 I=1,NGATE
      J=JGATE(I)
      N=NCHAN(J,1)
      LINK=NCHAN(J,2)
      QP(LINK)=QP(N)
C**** CHECK FOR OUTFALL PIPE ON AN ADVERSE SLOPE
      JUP=1
      JDN=2
      IF(NJUNC(N,2).EQ.J) GO TO 1010
      QP(LINK)=-QP(LINK)
      JUP=2
      JDN=1
 1010 IF(H(N,JUP)-HTIDE) 1020,1020,1030
C******** GATE CLOSED
 1020 YDEPT(J)=H(N,JUP)-Z(J)
      IF(YDEPT(J).LT.0.)YDEPT(J)=0.
      GO TO 1060
C******** GATE OPEN
 1030 CALL DEPTH(N,NKLASS(N),QP(N),YCRIT,YNORM,TIME,ICYC)
      YDEPT(J)=AMIN1(YCRIT,YNORM)
C******** CHECK FOR FULL PIPE OR SURCHARGE
      IF(YDEPT(J).GT.DEEP(N)) YDEPT(J)=DEEP(N)
C******** CHECK FOR TIDE ELEVATION
      IF((YDEPT(J)+Z(J)).LT.HTIDE) YDEPT(J)=HTIDE-Z(J)
 1060 CONTINUE
C
 1080 RETURN
      END
```

```
      SUBROUTINE DEPTH (N,KLASS,QPO,YC,YNORM,TIME,ICYC)
C
C                THIS SUBROUTINE FINDS THE CRITICAL DEPTH
C                AND THE NORMAL DEPTH CORRESPONDING TO THE FLOW QP
C
      COMMON /BD/ANORM(26,5),HRNORM(26,5),TWNORM(26,5)
C
        COMMON/FILES/ N5,N6,N21,N22,NPOLL
      COMMON/PIPE/LEN(187),NJUNC(187,2),AFULL(187),AT(187),
     1 Q(187),V(187),VT(187),DEEP(187),A(187),WIDE(187),RFULL(187),
     2 NKLASS(187),ZP(187,2),QT(187),QO(187),H(187,2),NCOND(187),
     3 ROUGH(187)
      COMMON/TRAP/STHETA(200),SPHI(200)
      DIMENSION KCRIT(187)
      REAL LEN
C
C                         E X E C U T I O N
C
      QP=ABS(QPO)
      YC=0.
      YNORM=0.
      IF(QP.LE.0.) RETURN
      NDIM=187
      NTYPE=KLASS
      IF(NTYPE.EQ.6) GO TO 640
C******** SPECIFY NTYPE FOR ORIFICES
      IF(NKLASS(N).EQ. 7 .OR. NKLASS(N).EQ. 8) NTYPE=1
C*********INITIALIZE KCRIT
C
      IF(ICYC.GT.1) GO TO 100
      DO 50 I=1,NDIM
      KCRIT(I)=0
   50 CONTINUE
C******** SEARCH AREA * WIDTH TABLES FOR PROPER LOCATION
  100 QCO=0.
      DO 300 I=2,26
      AREA=AFULL(N)*ANORM(I,NTYPE)
      WIDTH=WIDE(N)*TWNORM(I,NTYPE)
      QC=AREA*SQRT(32.2*AREA/WIDTH)
      IF(QC-QP) 250,200,200
  200 DELTA=(QP-QCO)/(QC-QCO)
      YC=0.04*(FLOAT(I-2)+DELTA)*DEEP(N)
      GO TO 400
  250 QCO=QC
  300 CONTINUE
C
C******** PIPE SURCHARGED AT THIS SECTION
      YC=DEEP(N)
C
C******** SEARCH AREA * RADIUS TABLES FOR PROPER LOCATION
  400 QNORMO=0.
      DO 600 I=2,26
      AREA=AFULL(N)*ANORM(I,NTYPE)
      HRAD=RFULL(N)*HRNORM(I,NTYPE)
      IF(NTYPE.EQ. 2) HRAD=WIDE(N)+2.*(I-1)/25.*DEEP(N)
      QNORM=SQRT(32.2*(ZP(N,1)-ZP(N,2))/(LEN(N)*ROUGH(N)))
```

```
     1 *AREA*HRAD**0.6667
      IF(QNORM-QP) 550,500,500
  500 DELTA=(QP-QNORMO)/(QNORM-QNORMO)
      YNORM=0.04*(FLOAT(I-2)+DELTA)*DEEP(N)
      GO TO 620
  550 QNORMO=QNORM
  600 CONTINUE
C******** PIPE SURCHARGED AT THIS SECTION
      YNORM=DEEP(N)
C
  620 RETURN
C
C******** YC AND YNORM FOR TRAPEZOIDAL CHANNELS
C
C**** COMPUTE YC
  640 QCO=0.
      DO 660 I=2,26
      YI=0.04*FLOAT(I-1)*DEEP(N)
      WIDTH=YI*(STHETA(N)+SPHI(N))+WIDE(N)
      AREA=0.5*YI*(WIDTH+WIDE(N))
      QC=AREA*SQRT(32.2*AREA/WIDTH)
      IF(QC-QP) 650,645,645
  645 DELTA=(QP-QCO)/(QC-QCO)
      YC=0.04*(FLOAT(I-2)+DELTA)*DEEP(N)
      GO TO 670
  650 QCO=QC
  660 CONTINUE
C
C**** PIPE SURCHARGED AT THIS SECTION
      YC=DEEP(N)
C
C**** COMPUTE YNORM
      QNORMO=0.
      SROOTS=SQRT(1.+STHETA(N)**2.)+SQRT(1.+SPHI(N)**2.)
      DO 680 I=2,26
      YI=0.04*FLOAT(I-1)*DEEP(N)
      AREA=YI*(WIDE(N)+YI/2.*(STHETA(N)+SPHI(N)))
      HRAD=AREA/(WIDE(N)+DTEMP*SROOTS)
      QNORM=SQRT(32.2*(ZP(N,1)-ZP(N,2))/(LEN(N)*ROUGH(N)))*AREA*HRAD**0.
     2677
      IF(QNORM-QP) 675,670,670
  670 DELTA=(QP-QNORMO)/(QNORM-QNORMO)
      YNORM=0.04*(FLOAT(I-2)+DELTA)*DEEP(N)
      RETURN
  675 QNORMO=QNORM
  680 CONTINUE
C**** PIPE SURCHARGED AT THIS SECTION
      YNORM=DEEP(N)
      RETURN
      END
```

Subroutine HEAD

Subroutine HEAD is used to convert a nodal water depth to the depth of flow above the invert of a connecting pipe. Based on the depths of flow at each pipe end, HEAD computes the surface width and assigns surface area to the upstream and downstream node according to the following criteria:

1. For the normal situation in which both pipe inverts are submerged and the flow is sub-critical throughout the conduit, the surface area of that conduit is assigned equally to the two connecting junctions.
2. If a critical flow section is detected at the downstream end of a conduit, then surface area for that conduit is assigned to the upstream node.
3. If a critical section occurs at the upstream end, the conduit surface area is assigned to the downstream node.
4. For a dry pipe (pipe inverts unsubmerged), the surface area is zero. The velocity, cross-sectional area and hydraulic radius are set to zero for this case.
5. If the pipe is dry only at the upstream end, then all surface area for the conduit is assigned to the downstream junction.

Note that adverse flow in the absence of a critical section is treated as in (1) above. If a critical section occurs upstream, then all surface area for the adverse pipe is assigned downstream as in (3). The assignment of nodal surface area, based on the top width and length of conduit flow, is essential to the proper calculation of head changes computed at each node from mass continuity as discussed in Chapter 3. Following surface area assignment, HEAD computes the current weighted average values of cross-sectional area, flow, velocity, and hydraulic radius for each pipe. Subroutine HEAD is called by program MAIN and it in turn uses subroutines DEPTH and HYDRAD in its surface area computations, as shown in the computer listing which follows.

```
      SUBROUTINE HEAD(N,NL,NH,HEAD1,HEAD2,QP,AREA,VEL,HRAD,ANH,ANL,RNL,
     1TIME,ICYC)
C
C                 THIS SUBROUTINE CONVERTS NODAL DEPTHS TO PIPE DEPTHS
C                 IT ALSO ASSIGNS SURFACE AREAS TO THE PROPER NODES
C                 SURFACE AREA IS NOT ASSIGNED TO ORIFICE OR WEIR LINKS
C
      COMMON /BD/ANORM(26,5),HRNORM(26,5),TWNORM(26,5)
        COMMON/FILES/ N5,N6,N21,N22,NPOLL
      COMMON/TRAP/STHETA(200),SPHI(200)
      COMMON/JUNC/Y(187),YT(187),NCHAN(187,8),AS(187),Z(187),QIN(187),
     1 QOU(187),QINST(187),GRELEV(187),JUN(187),ZCROWN(187),JSKIP(187)
     2 ,SUMAL(187),SUMQ(187),SUMQS(187),ASFULL(187)
C
      COMMON/PIPE/LEN(187),NJUNC(187,2),AFULL(187),AT(187),
     1 Q(187),V(187),VT(187),DEEP(187),A(187),WIDE(187),RFULL(187),
     2 NKLASS(187),ZP(187,2),QT(187),QO(187),H(187,2),NCOND(187),
     3 ROUGH(187)
      REAL LEN
C
C                              E X E C U T I O N
C
      YNL=HEAD1-ZP(N,1)
      YNH=HEAD2-ZP(N,2)
C
C******** CHECK FOR DRY PIPE
      IF(YNL.LE.0..AND.YNH.LE.0.)  GO TO 220
      IF(YNL)10,10,20
C******** YNL.LE.0, YNH..GT.0 (CRIT OR NORM UPSTRM OR STORAGE DWNSTRM)
   10 IF(HEAD2-ZP(N,1)) 240,15,15
   15 IF(ZP(N,1).LE.Z(NL)) GO TO 160
      CALL DEPTH(N,NKLASS(N),QP,YC,YNORM,TIME,ICYC)
      GO TO 200
C******** YNH LE 0, YNL GT 0, CRITICAL OR NORM DOWNSTREAM
   20 IF(YNH) 25,25,30
   25 IF(ZP(N,2).LE.Z(NH)) GO TO 160
      CALL DEPTH(N,NKLASS(N),QP,YC,YNORM,TIME,ICYC)
      Y2=AMIN1(YC,YNORM)
      GO TO 180
C******** YNL AND YNH GT 0
   30 IF(QP) 35,50,50
C******** ADVERSE FLOW
   35 IF(ZP(N,1)-Z(NL)) 160,160,40
   40 CALL DEPTH(N,NKLASS(N),QP,YC,YNORM,TIME,ICYC)
      IF(YC-YNL) 160,160,200
C******** POSITIVE FLOW
   50 IF(ZP(N,2)-Z(NH)) 160,160,55
   55 CALL DEPTH(N,NKLASS(N),QP,YC,YNORM,TIME,ICYC)
      Y2=AMIN1(YC,YNORM)
      IF(Y2-YNH) 120,120,180
  120 IF(YNH-AMAX1(YC,YNORM)) 140,140,160
  140 FASNH=(YNH-Y2)/ABS(YNORM-YC)
      GO TO 165
C
C******** NORMAL SITUATION' HALF SURFACE AREA AT EACH END
  160 FASNH=1.0
```

```
  165 YMID=0.5*(YNL+YNH)
      IF (YMID.LE.0.0) YMID=0.0
      CALL HYDRAD(N,NKLASS(N),YNL,RNL,ANL,BNL)
      CALL HYDRAD(N,NKLASS(N),YMID,RMID,AMID,BMID)
      CALL HYDRAD(N,NKLASS(N),YNH,RNH,ANH,BNH)
      IF(NKLASS(N).GT. 6) GO TO 260
      AS(NL)=AS(NL)+0.25*(BNL+BMID)*LEN(N)
      AS(NH)=AS(NH)+0.25*(BMID+BNH)*LEN(N)*FASNH
      GO TO 260
C
C******** CRITICAL SECTION DOWNSTREAM' SURFACE AREA UPSTREAM
  180 YNH=Y2
      HEAD2=YNH+ZP(N,2)
      YMID=0.5*(YNL+YNH)
      IF (YMID.LE.0.0)  YMID=0.0
      CALL HYDRAD(N,NKLASS(N),YNL,RNL,ANL,BNL)
      CALL HYDRAD(N,NKLASS(N),YMID,RMID,AMID,BMID)
      CALL HYDRAD(N,NKLASS(N),YNH,RNH,ANH,BNH)
      IF(NKLASS(N).GT. 6) GO TO 260
      AS(NL)=AS(NL)+0.25*(BNL+BMID)*LEN(N)
      GO TO 260
C
C******** CRITICAL SECTION UPSTREAM' SURFACE AREA DOWNSTREAM
  200 HEAD1=YC+ZP(N,1)
      YNL=YC
      YMID=0.5*(YNL+YNH)
      IF (YMID.LE.0.0)  YMID=0.0
      CALL HYDRAD(N,NKLASS(N),YNL,RNL,ANL,BNL)
      CALL HYDRAD(N,NKLASS(N),YMID,RMID,AMID,BMID)
      CALL HYDRAD(N,NKLASS(N),YNH,RNH,ANH,BNH)
      IF(NKLASS(N).GT. 6) GO TO 260
      AS(NH)=AS(NH)+0.25*(BMID+BNH)*LEN(N)
      GO TO 260
C
C******** DRY PIPE' NO SURFACE AREA FOR ENDS WITH NEGATIVE Y
  220 HEAD1=HEAD2
      YMID=0.
      CALL HYDRAD(N,NKLASS(N),YMID,RMID,AMID,BMID)
      ANH=0.
      ANL=0.
      RNL=0.
      AREA=0.
      VEL=0.
      HRAD=.01
      QO(N)=0.0
      IF(NKLASS(N).GT. 6) RETURN
      IF(YNL.LT.-0.001) GO TO 230
      AS(NL)=AS(NL)+BMID*LEN(N)/2.
  230 IF(YNH.LT.-0.001) RETURN
      AS(NH)=AS(NH)+BMID*LEN(N)/2.

      RETURN
C
C******** DRY UPSTREAM' SURFACE AREA DOWNSTREAM
  240 HEAD1=HEAD2
      YNL=0.
```

```
      YMID=HEAD2-0.5*(ZP(N,1)+ZP(N,2))
      IF(YMID.LT.0.) YMID=0.
      CALL HYDRAD(N,NKLASS(N),YNL,RNL,ANL,BNL)
      CALL HYDRAD(N,NKLASS(N),YMID,RMID,AMID,BMID)
      CALL HYDRAD(N,NKLASS(N),YNH,RNH,ANH,BNH)
      AREA=0.25*(ANL+2.*AMID+ANH)
      VEL=0.0
      HRAD=0.5*(RMID+RNH)
      QO(N)=0.0
      IF(NKLASS(N).GT. 6) RETURN
      AS(NH)=AS(NH)+0.25*(BMID+BNH)*LEN(N)
      IF(ZP(N,1)-Z(NL).LT.0.001) AS(NL)=AS(NL)+.25*(BNL+BMID)*LEN(N)
      RETURN
C
C******** COMPUTE CROSS-SECTION AREA, VELOCITY * HYDRAULIC RADIUS
  260 AREA=0.25*(ANL+2.*AMID+ANH)
      VEL=0.
      IF(AREA.GT.0.) VEL=QP/AREA
      HRAD=0.25*(RNL+2.*RMID+RNH)
      IF (AREA.LE.0.0) QO(N)=0.0
      RETURN
      END
```

Subroutine HYDRAD

The function of subroutine HYDRAD is to compute average values of hydraulic radius, cross-sectional area, and surface width for all conduits in the transport system. Based on the current water depth at the ends and mid-point of each conduit, HYDRAD computes from a table of normalized properties the current value of hydraulic radius, cross-sectional area, and surface width. HYDRAD is used by subroutine HEAD for computing nodal surface areas as described above. It is also called by BOUND for computing the cross-sectional area and average velocity of flow in the outfall pipe protected by a tide gate. The following computer listing shows the details of these computations.

Subroutine INDATA

INDATA is the principal input data subroutine for the Analysis Module which is used once at the beginning of the MAIN program. Its primary function is to read all input data specifying the links, nodes and special structures of the transport network. It also establishes sewer system connectivity and sets up an internal numbering system for all sewer elements by which the computations in MAIN can be carried out. The principal operations of INDATA are listed in the order they occur in the program:

1. Read first two title cards for output headings and run control card specifying the number of integration cycles, the length of the time step, TZERO, and other parameters for output control.
2. Read external junction and conduit numbers for detailed printing and plotting of simulation output.
3. Read physical data for conduits and print a summary of all conduit data.
4. Read physical data for junctions and print summary of all junction data.

```
      SUBROUTINE HYDRAD (N,KLASS,DEPTH,HRAD,AREA,WIDTH)
C
C                 THIS SUBROUTINE COMPUTES THE HYDRAULIC RADIUS,
C                 SURFACE WIDTH, * CROSS-SECTION AREA FOR PIPE 'N'
C
        COMMON/FILES/ N5,N6,N21,N22,NPOLL
      COMMON /BD/ANORM(26,5),HRNORM(26,5),TWNORM(26,5)
C
      COMMON/PIPE/LEN(187),NJUNC(187,2),AFULL(187),AT(187),
     1 Q(187),V(187),VT(187),DEEP(187),A(187),WIDE(187),RFULL(187),
     2 NKLASS(187),ZP(187,2),QT(187),QO(187),H(187,2),NCOND(187),
     3 ROUGH(187)
      COMMON/TRAP/STHETA(200),SPHI(200)
      REAL LEN
C
C                            E X E C U T I O N
C
      NTYPE=KLASS
      IF(DEPTH) 200,100,100
C**** SPECIFY NTYPE FOR ORIFICES
  100 IF(NKLASS(N).EQ. 7 .OR. NKLASS(N).EQ. 8) NTYPE=1
      GO TO (120,180,120,120,120,190),NTYPE
  120 FDEPTH=DEPTH/DEEP(N)
      IF(FDEPTH-1.) 140,140,160
C
C******** INTERPOLATE TABLE OF PROPERTIES
  140 I=1+IFIX(FDEPTH/0.04)
      DELTA=(FDEPTH-0.04*FLOAT(I-1))/0.04
      WIDTH = WIDE(N)*(TWNORM(I,NTYPE)+(TWNORM(I+1,NTYPE)-TWNORM(I,NTYPE
     1))*DELTA)
      AREA = AFULL(N)*(ANORM(I,NTYPE) + (ANORM(I+1,NTYPE)-ANORM(I,NTYPE)
     1)*DELTA)
      HRAD = RFULL(N)*(HRNORM(I,NTYPE)+(HRNORM(I+1,NTYPE)-HRNORM(I,NTYPE
     1))*DELTA)
      RETURN
C
C******** FULL PIPE
  160 WIDTH = 0.
      AREA=AFULL(N)
      HRAD=RFULL(N)
      RETURN
C******** RECTANGULAR SECTION (SPECIAL CASE)
C
  180 WIDTH=WIDE(N)
      AREA=WIDTH*DEPTH
      HRAD=AREA/(WIDTH+2.*DEPTH)
      HRAD=AMAX1(HRAD,0.01)
      RETURN
C
C******** TRAPEZOIDAL SECTION (SPECIAL CASE)
  190 CONTINUE
      DEPTT=DEPTH
      FDEP=DEPTH-DEEP(N)
      IF(FDEP) 196,196,194
  194 DEPTT=DEEP(N)
  196 CONTINUE
```

```
      WIDTH=WIDE(N)+DEPTT*(STHETA(N)+SPHI(N))
      AREA=DEPTT*(WIDE(N)+(DEPTT/2.)*(STHETA(N)+SPHI(N)))
      WETPER=WIDE(N)+DEPTT*(SQRT(1.+STHETA(N)**2.)+SQRT(1.+SPHI(N)**2.))
      HRAD=AREA/WETPER
      HRAD=AMAX1(HRAD,0.01)
      RETURN
C
C******** NEGATIVE DEPTH
  200 WRITE(N6,5000) NCOND(N),DEPTH
 5000 FORMAT('ONEGATIVE DEPTH ENTERED TO HYDRAD, COND.',I6,E16.4)
      DEPTH=0.
      GO TO 100
      END
```

5. Set up internal numbering system for junctions and conduits and establish connectivity matrix. This matrix shows the connecting nodes at the ends of each conduit and conversely the connecting links for each node in the storm sewer system.

6. Read orifice input data and print summary. Assign internal link between orifice node and node to which it discharges.

7. Read weir input data and assign an internal link and node to each weir in the system. Print summary of all weir data.

8. Read pump data and assign an internal link number to each pump node. Print summary of all pumping input data. Set invert elevation and inflow index for pumped node.

9. Read free outfall data and print a data summary for outfalls. Assign an internal link for each free outfall in the internal numbering system.

10. Read tide gated (non-weir) outfall data from cards and print a summary of tide gate data. Assign an internal link for each free outfall in the internal numbering system.

11. Print a summary of internal connectivity information showing the internal nodes and connecting links assigned to orifices, weirs, pumps, and free outfalls.

12. Read tidal boundary input data. Depending on the tidal index, one of the following four boundary conditions will exist:

    - No control water surface at the system outfalls;

    - All outfall control water surfaces at the same constant elevation, A1;

- Tide coefficient read in by cards; or
- Tide coefficients A1 through A7 will be generated by subroutine TIDCF based on a set of tidal stage and time points.

Print summary of tidal boundary input data, including the tide coefficients generated by TIDCF which are printed in subroutine TIDCF.

13. Set up print and plot arrays for output variables in the internal numbering system.
14. Initialize conduit conveyance factor in Manning equation. Also, read input data defining the initial conduit flows, velocities, and junction depths at TZERO corresponding to DWF or some antecedent flow condition.
15. Read first two hydrograph records either from tape unit N21 supplied by the Surface Runoff Program or from data input cards.

The code which performs these functions is shown in the following computer listing.

Subroutine INFLOW

Subroutine INFLOW is called from the MAIN program on each time-step to compute the current value of hydrograph inflow to each input node in the sewer system. INFLOW reads current values of hydrograph ordinates from tape unit N21 when the Surface Runoff Program is used or from card input runoff hydrographs in cases where the Surface Runoff Program is not used as a preprocessor to the Analysis Module. INFLOW performs a linear interpolation between hydrograph input points and computes the discharge at each input node at the half-step time, $t+\Delta t/2$. A listing of INFLOW follows.

```
      SUBROUTINE INDATA
C
C                 THIS SUBROUTINE READS AND PRINTS ALL INPUT DATA
C                 EXCEPT FOR HYDROGRAPH CARDS IN 'INFLOW'
C                 IT ALSO PERFORMS SOME INITIALIZATION
C                 ALL NODE-CONDUIT LINKAGES ARE SET UP AND
C                 CONVERTED TO THE INTERNAL NUMBER SYSTEM
C
        INTEGER IFNAM(3),OFNAM(3),IHFNM(3),INQTM(3)
      COMMON /BD/ANORM(26,5),HRNORM(26,5),TWNORM(26,5)
C
        COMMON/FILES/ N5,N6,N21,N22,NPOLL
      COMMON/CONTR/ NTCYC,DELTQ,DELT,DELT2,TZERO,ALPHA(30),
     1 NJ,NC,NTC,NTL,ICYC,NJSW,MJSW,TIME,TIME2,A1,A2,A3,A4,A5,A6,A7,W
C
      COMMON/JUNC/Y(187),YT(187),NCHAN(187,8),AS(187),Z(187),QIN(187),
     1 QOU(187),QINST(187),GRELEV(187),JUN(187),ZCROWN(187),JSKIP(187)
     2 ,SUMAL(187),SUMQ(187),SUMQS(187),ASFULL(187)
C
      COMMON/PIPE/LEN(187),NJUNC(187,2),AFULL(187),AT(187),
     1 Q(187),V(187),VT(187),DEEP(187),A(187),WIDE(187),RFULL(187),
     2 NKLASS(187),ZP(187,2),QT(187),QO(187),H(187,2),NCOND(187),
     3 ROUGH(187)
      COMMON/TRAP/STHETA(200),SPHI(200)
C
      REAL LEN
C
      COMMON/STORE/ NSTORE,JSTORE(20),ZTOP(20),ASTORE(20)
      COMMON/ORF/ NORIF,LORIF(60),AORIF(60),CORIF(60)
      COMMON/WEIR/ NWEIR,LWEIR(60),KWEIR(60),YTOP(60),YCREST(60),
     2 WLEN(60),COEF(60),COEFS(60)
      COMMON/PUMP/ NPUMP,LPUMP(20),PRATE(20,3),VRATE(20,3),VWELL(20),
     1 JPFUL(20),IPTYP(20)
      COMMON/BND/ NFREE,JFREE(25),NTIDE,JTIDE(25),NGATE,JGATE(25)
C
      COMMON/OUT/ NPRT,IPRT,NHPRT,JPRT(20),PRTH(100,20),PRGEL(20),
     1 NQPRT,CPRT(20),PRTV(100,20),PRTQ(100,20),IDUM(12),ICOL(10),
     2 LTIME,NPLT,JPLT(20),YPLT(102,20),LPLT,KPLT(20),QPLT(102,20),
     3 TPLT(102),NPTOT,NSTART,INTER,PRTY(100,20)
      INTEGER CPRT
C
      COMMON/TIDE/ YY(50) ,TT(50) ,AA(10),XX(10),SXX(10,10),SXY(10)
C
      COMMON/HYFLOW/ ISW(187),QTAPE(187,2),JSW(65),QCARD(65,2),
     1 WATSH(187),TEO,TP,T2,TE,T20,TIMEO,NSTEPS,NINREC
C
      COMMON/LAB/ TITLE(40),XLAB(11),YLAB(6),HORIZ(5),VERT(6)
C
C
      DIMENSION OTYPE(2)
C
      DATA OTYPE/'SIDE','SUMP'/
      DATA ENOTE/6HERROR ,6HERRORS/
C
C                        E X E C U T I O N
C
```

```
C********  TAPE ASSIGNMENTS
      N5=20
      N6=21
      N22=0
      NSTOP=0
      NDIM=187
        WRITE(5,103)
 103    FORMAT(1X,'ENTER INPUT FILE SPECIFICATIONS:',$)
        READ(5,101)IFNAM
 101    FORMAT(3A5)
        WRITE(5,102)
 102    FORMAT(1X,'ENTER OUTPUT FILE SPECIFICATIONS:',$)
        READ(5,101)OFNAM
        OPEN(UNIT=N5,DEVICE='DSK',ACCESS='SEQIN',DIALOG=IFNAM)
        OPEN(UNIT=N6,DEVICE='DSK',ACCESS='SEQOUT',DIALOG=OFNAM)
C
C******** HEADING (TITLE) CARDS
C
      READ(N5,5040) ALPHA
 5040 FORMAT(15A4)
      WRITE(N6,2999)
2999  FORMAT('1',64(2H--)/' ','FEDERAL HIGHWAY ADMINISTRATION',14X,40H**
     2** URBAN HIGHWAY DRAINAGE PROGRAM ****,8X,'WATER RESOURCES DIVISIO
     3N'/' ','DEPARTMENT OF TRANSPORTATION',16X,4H****,32X,4H****,8X,
     4'CAMP DRESSER & MCKEE INC.'/' ','WASHINGTON, D.C.',28X,4H
     5****,6X,'   ANALYSIS MODULE   ',6X,4H****,8X,'ANNANDALE, VIRGINIA
     6')
      WRITE(N6,5060) ALPHA
 5060 FORMAT(' ',15A4/' ',15A4//)
C
C******** GENERAL CONTROL PARAMETERS
C
      READ(N5,5080) NTCYC,DELT,TZERO,NHPRT,NQPRT,NPLT,LPLT,NSTART,INTER,
     1 NJSW,N21,N22
 5080 FORMAT(I5,2F5.0,9I5)
C******** DEC 20 FILE SPECIFICATIONS
        IF(N21.LE.0)GO TO 110
        WRITE(N6,109)
 109    FORMAT(1X,'ENTER INPUT HYDROGRAPH FILE SPECIFICATIONS:',$)
        READ(5,101)IHFNM
        OPEN(UNIT=N21,DEVICE='DSK',ACCESS='SEQIN',DIALOG=IHFNM)
 110    IF(N22.LE.0)GO TO 118
        WRITE(N6,111)
 111    FORMAT(1X,'ENTER FILE SPECS FOR SYSTERM INFORMATION INPUT',
     1     ' TO QUALITY TRANSPORT MODEL:',$)
        READ(5,101)INQTM
        OPEN(UNIT=N22,DEVICE='DSK',ACCESS='SEQOUT',DIALOG=INQTM)
 118  DELT2=DELT/2.
      IF(N22.EQ.0)NJSW=0
      WRITE(N6,5100) NTCYC
 5100 FORMAT (19H0INTEGRATION CYCLES,I5)
      WRITE(N6,5120) DELT
 5120 FORMAT (30H0LENGTH OF INTEGRATION STEP IS,F6.0,8H SECONDS)
      IF (NSTART.LE.0)  NSTART = 1
      INTEMP=(NTCYC-NSTART)/100 + 1
      IF (INTEMP.GE.INTER) INTER=INTEMP
```

```
      WRITE(N6,5140) NSTART,INTER
 5140 FORMAT('0PRINTING STARTS IN CYCLE',I5,' AND PRINTS AT INTERVALS OF
     1',I4,' CYCLES')
      WRITE(N6,5160) TZERO
 5160 FORMAT (13H0INITIAL TIME,F6.2,6H HOURS)
      TZERO=3600.*TZERO
C
C******** PRINT AND PLOT DATA
C
C******** JUNCTION NUMBERS FOR DETAILED PRINTOUT
      READ(N5,5180)(JPRT(I),I=1,NHPRT)
 5180 FORMAT(8I10)
      WRITE(N6,5200)NHPRT,(JPRT(I),I=1,NHPRT)
 5200 FORMAT (32H0PRINTED OUTPUT AT THE FOLLOWING,I3,10H JUNCTIONS,//
     1 (10X,9I10))
C******** CONDUIT NUMBERS FOR DETAILED PRINTOUT
      READ(N5,5180)(CPRT(I),I=1,NQPRT)
      WRITE(N6,5220)NQPRT,(CPRT(I),I=1,NQPRT)
 5220 FORMAT (/,11X,'AND FOR THE FOLLOWING',I3,' CONDUITS'//(10X,9I10))
C******** JUNCTION NUMBERS FOR PLOTTING
      IF (NPLT.LE.0) GO TO 100
      READ (N5,5180) (JPLT(N),N=1,NPLT)
      WRITE(N6,5240) NPLT,(JPLT(N),N=1,NPLT)
 5240 FORMAT ('0WATER SURFACE ELEVATIONS WILL BE PLOTTED FOR THE FOLLOWI
     1NG ',I5,' JUNCTIONS'//(10X,9I10))
C******** CONDUIT NUMBERS FOR PLOTTING
  100 IF (LPLT.LE.0) GO TO 120
      READ (N5,5180) (KPLT(N),N=1,LPLT)
      WRITE(N6,5260) LPLT,(KPLT(N),N=1,LPLT)
 5260 FORMAT('0FLOW RATE WILL BE PLOTTED FOR THE FOLLOWING',I5,' CONDUIT
     1S'//(10X,9I10))
  120 CONTINUE
C
C******** CONDUIT DATA
C
      DO 260 N=1,NDIM
      READ (N5,5280) NCOND(N),(NJUNC(N,K),K=1,2),NKLASS(N),AFULL(N)
     1 ,DEEP(N),WIDE(N),LEN(N),(ZP(N,K),K=1,2),ROUGH(N),STHETA(N),
     2 SPHI(N)
 5280 FORMAT (4I5,9F5.0)
      IF (NCOND(N).GT.90000) GO TO 280
      IF(ROUGH(N) .LE. 0.0) ROUGH(N) = 0.014
      KLASS=NKLASS(N)
C                    NKLASS=1 CIRCULAR PIPE
C                    NKLASS=2 RECTANGULAR PIPE
C                    NKLASS=3 HORSESHOE PIPE
C                    NKLASS=4 EGGSHAPED PIPE
C                    NKLASS=5 BASKETHANDLE PIPE
C                    NKLASS=6  TRAPEZOIDAL CHANNEL
C                    NKLASS=7-8 ORIFICES (SEE BELOW)
      GO TO (140,160,180,200,220,230),KLASS
  140 RFULL(N)=DEEP(N)/4.
      AFULL(N)=(3.1415926/4.)*DEEP(N)**2
      WIDE(N)=DEEP(N)
      GO TO 240
  160 RFULL(N)=(WIDE(N)*DEEP(N))/(2.*WIDE(N)+2.*DEEP(N))
```

```
      AFULL(N)=WIDE(N)*DEEP(N)
      GO TO 240
  180 RFULL(N)=0.25381*DEEP(N)
      GO TO 240
  200 RFULL(N)=0.19311*DEEP(N)
      GO TO 240
  220 RFULL(N)=0.28800*DEEP(N)
      GO TO 240
  230 AFULL(N)=DEEP(N)*(WIDE(N)+DEEP(N)/2.*(STHETA(N)+SPHI(N)))
      RFULL(N)=AFULL(N)/(WIDE(N)+DEEP(N)*(SQRT(1.+STHETA(N)**2.)
     1 +SQRT(1.+SPHI(N)**2.)))
      IF(WIDE(N).LE.0.) WIDE(N) = 0.01
  240 CONTINUE
  260 CONTINUE
  280 NC=N-1
      NTC=NC
C******** PRINT CONDUIT DATA
      WRITE(N6,2999)
      WRITE(N6,5060) ALPHA
      WRITE(N6,5300)
 5300 FORMAT(1H ,'      CONDUIT   LENGTH   CLASS     AREA    MANNING
     1   MAX WIDTH       DEPTH   JUNCTIONS        INVERT HEIGHT        T
     2RAPEZOID'/,
     27X,'NUMBER     (FT)              (SQ FT)   COEF.           (FT)
     3     (FT)     AT ENDS        ABOVE JUNCTIONS       SIDE SLOPE')
      NSPRT=-1
      DO 300 N=1,NC
      IF((ZP(N,1).EQ.0.).AND.(ZP(N,2).EQ.0.)) GO TO 296
      GO TO 297
  296 IF(NKLASS(N).EQ.6) WRITE(N6,5320)N,NCOND(N),LEN(N),NKLASS(N),
     *AFULL(N),ROUGH(N),WIDE(N),DEEP(N),(NJUNC(N,K),K=1,2),
     *STHETA(N),SPHI(N)
      IF(NKLASS(N).NE.6) WRITE(N6,5321)N,NCOND(N),LEN(N),NKLASS(N),
     *AFULL(N),ROUGH(N),WIDE(N),DEEP(N),(NJUNC(N,K),K=1,2)
      GO TO 300
  297 IF(NKLASS(N).EQ.6) WRITE(N6,5322)N,NCOND(N),LEN(N),NKLASS(N),
     *AFULL(N),ROUGH(N),WIDE(N),DEEP(N),(NJUNC(N,K),K=1,2),
     *(ZP(N,K),K=1,2),STHETA(N),SPHI(N)
      IF(NKLASS(N).NE.6) WRITE(N6,5323)N,NCOND(N),LEN(N),NKLASS(N),
     *AFULL(N),ROUGH(N),WIDE(N),DEEP(N),(NJUNC(N,K),K=1,2),
     *(ZP(N,K),K=1,2)
 5320 FORMAT(I4,I9,F9.0,I7,F12.2,F9.3,F15.2,F13.2,2X,2I6,
     *28X,2F5.2)
 5321 FORMAT(I4,I9,F9.0,I7,F12.2,F9.3,F15.2,F13.2,2X,2I6)
 5322 FORMAT(I4,I9,F9.0,I7,F12.2,F9.3,F15.2,F13.2,2X,2I6,8X,F5.2,
     *2X,F5.2,8X,2F5.2)
 5323 FORMAT(I4,I9,F9.0,I7,F12.2,F9.3,F15.2,F13.2,2X,2I6,8X,F5.2,
     *2X,F5.2)
  300 CONTINUE
C
C******** CHECK FOR VIOLATION OF WAVE TRAVEL/CONDUIT LENGTH RATIO
      DO 320 N=1,NC
      RATIO=SQRT(DEEP(N)*32.2)*DELT/LEN(N)
      IF(RATIO.GT.1.)WRITE(N6,5335)NCOND(N),RATIO
 5335 FORMAT(' **** WARNING **** (C*DELT/LEN) IN CONDUIT',
     *       I6,' IS',F5.1,' AT FULL DEPTH.')
```

```
  320 CONTINUE
C
C******** JUNCTION DATA
C
      DO 380 J=1,NDIM
      READ (N5,5340) JUN(J),GRELEV(J),Z(J),QINST(J)
 5340 FORMAT (I5,3F5.0)
      IF (JUN(J).GT.90000) GO TO 400
      ZCROWN(J)=Z(J)
      JSKIP(J)=0
C******** SET UP JUNCTION CONNECTIVITY ARRAY FROM PIPE DATA
      LOC=1
      SUMAL(J)=0.
      DO 360 N=1,NC
      DO 360 K=1,2
      IF(NJUNC(N,K)-JUN(J)) 360,340,360
  340 NCHAN(J,LOC)=N
      LOC=LOC+1
  360 CONTINUE
      IF(LOC.GT.1) GO TO 380
      WRITE(N6,5350) JUN(J)
 5350 FORMAT('0**** WARNING **** JUNCTION',I6,' IS NOT ASSOCIATED WITH '
     .       'ANY PIPE')
      JSKIP(J)=1
  380 CONTINUE
  400 NJ=J-1
C
C******** CONVERT CONDUIT CONNECTIVITY NUMBERS TO INTERNAL SYSTEM
C******** ASSIGN POSITIVE DOWNSTREAM FLOW CONVENTION
      DO 600 N=1,NC
      DO 540 K=1,2
      DO 500 J=1,NJ
      IF(NJUNC(N,K)-JUN(J)) 500,520,500
  500 CONTINUE
      WRITE(N6,5390) NJUNC(N,K),NCOND(N)
 5390 FORMAT('0**** ERROR **** JUNCTION',I6,' ON CONDUIT',I6,' IS NOT '
     .       'CONTAINED IN JUNCTION DATA')
      NSTOP=NSTOP+1
  520 NJUNC(N,K)=J
  540 CONTINUE
      NL=NJUNC(N,1)
      NH=NJUNC(N,2)
      ZP(N,1) = Z(NL) + ZP(N,1)
      ZP(N,2)=Z(NH)+ZP(N,2)
      IF(ZP(N,1)-ZP(N,2)) 560,580,580
  560 TEMP=ZP(N,1)
      ZP(N,1)=ZP(N,2)
      ZP(N,2)=TEMP
      NJUNC(N,1) = NH
      NJUNC(N,2)=NL
      NL=NJUNC(N,1)
      NH=NJUNC(N,2)
  580 IF((ZP(N,1)+DEEP(N)).GT.ZCROWN(NL)) ZCROWN(NL)=ZP(N,1)+DEEP(N)
      IF((ZP(N,2)+DEEP(N)).GT.ZCROWN(NH)) ZCROWN(NH)=ZP(N,2)+DEEP(N)
```

```
      IF(ZCROWN(NL).LE.GRELEV(NL)+0.001) GO TO 590
      WRITE(N6,5395) NCOND(N),JUN(NL)
      ZCROWN(NL)=GRELEV(NL)-0.01
      NSTOP=NSTOP+1
  590 IF(ZCROWN(NH).LE.GRELEV(NH)+0.001) GO TO 600

      WRITE(N6,5395) NCOND(N),JUN(NH)
 5395 FORMAT('0**** ERROR **** CONDUIT',I6,' HAS CAUSED ZCROWN OF '
     .       'JUNCTION',I6,' TO LIE ABOVE THE SPECIFIED GROUND ELEV.')
      ZCROWN(NH)=GRELEV(NH)-0.01
      NSTOP=NSTOP+1
  600 CONTINUE
C******** PRINT JUNCTION DATA
      WRITE(N6,2999)
      WRITE(N6,5060) ALPHA
      WRITE(N6,5360)
 5360 FORMAT(1H ,5X,'JUNCTION    GROUND     CROWN     INVERT     QINST'
     1,15X,'CONNECTING CONDUITS'/7X,'NUMBER',7X,'ELEV.',5X,'ELEV.',6X,
     1'ELEV.',5X,'(CFS)'/)
      DO 460 J=1,NJ
      MPT=0
      NZP = 0
      DO 420 I=1,8
      K1 = NCHAN(J,I)
      IF(K1.EQ.0) GO TO 440
      IDUM(I) = NCOND(K1)
      MPT=MPT+1
C******** CHECK FOR ALL CONDUITS ABOVE JUNCTION INVERT
      JJ = 0
      IF(NJUNC(K1,1).EQ.J) JJ = 1
      IF(JJ.NE.1) JJ = 2
      IF(ZP(K1,JJ).GT.Z(J)) NZP = NZP + 1
  420 CONTINUE
  440 CONTINUE
C
      WRITE(N6,5380) J,JUN(J),GRELEV(J),ZCROWN(J),Z(J),QINST(J),
     1(IDUM(K),K=1,MPT)
 5380 FORMAT(I4,I9,F12.2,F10.2,F11.2,F10.2,15X,8I7)
      IF(NZP.LT.MPT) GO TO 450
      WRITE(N6,5381) JUN(J)
 5381 FORMAT(1X,'**** ERROR **** ALL CONDUITS CONNECTING',
     *' TO JUNCTION ',I6,' LIE ABOVE THE JUNCTION INVERT')
      NSTOP = NSTOP + 1
  450 CONTINUE
      QINST(J)=QINST(J)*DELT
  460 CONTINUE
  480 CONTINUE
      WRITE(N6,5382)
 5382 FORMAT(///,64(2H--)//)
C******** CHECK FOR HIGH PIPE
      DO 495 N=1,NC
      DO 495 K=1,2
      J = NJUNC(N,K)
      IF(ZP(N,K).EQ.Z(J)) GO TO 495
      DO 490 KK = 1,8
      NKK = NCHAN(J,KK)
```

```
      IF(NKK.EQ.N) GO TO 490
      IF(NKK.EQ.0.OR.NKK.GT.NC) GO TO 495
      JJ = 0
      IF(NJUNC(NKK,1).EQ.J) JJ = 1
      IF(JJ.NE.1) JJ = 2
      IF(ZP(N,K).LE.ZP(NKK,JJ) + DEEP(NKK)) GO TO 495
  490 CONTINUE
  491 WRITE(N6,5392) NCOND(N),JUN(J)
 5392 FORMAT(' ****** ERROR ****** THE INVERT OF ',
     *'CONDUIT',I6,' LIES ABOVE THE CROWN OF ALL OTHER ',
     *'CONDUITS AT JUNCTION',I6)
      NSTOP = NSTOP + 1
  495 CONTINUE
C
C******** STORAGE JUNCTION DATA
C
      DO 640 I=1,20
      READ(N5,5391) JSTORE(I),ZTOP(I),ASTORE(I)
 5391 FORMAT(I5,2F10.0)
      IF(JSTORE(I).GT.90000) GO TO 645
  640 CONTINUE
  645 NSTORE=I-1
      IF(NSTORE) 647,647,644
  644 WRITE(N6,2999)
      WRITE(N6,5060) ALPHA
      WRITE(N6,5398)
 5398 FORMAT('0',27(2H- ),'STORAGE JUNCTION DATA',27(2H -),/)
      WRITE(N6,5495)
 5495 FORMAT(1X,'STORAGE JUNCTION',6X,'SURFACE AREA',6X,'VOLUME',
     *6X,'CROWN ELEVATION',/,26X,'(FT2)',11X,'(CF)',12X,'(FT)')
C******** CONVERT TO INTERNAL NUMBER SYSTEM
      DO 646 I=1,NSTORE
      DO 648 J=1,NJ
      IF(JSTORE(I)-JUN(J)) 648,650,648
  648 CONTINUE
      WRITE(N6,5494) JSTORE(I)
 5494 FORMAT('0**** ERROR **** STORAGE JUNCTION ',I6,' IS NOT
     * CONTAINED IN JUNCTION DATA')
      NSTOP=NSTOP+1
  650 JSTORE(I)=J
      ZCROWN(J) = ZTOP(I)
      IF(ZCROWN(J).GT.GRELEV(J)) GRELEV(J) = ZCROWN(J) + 0.1
      JSKIP(J)=0
      CF = ASTORE(I)*(ZTOP(I)-Z(J))
      WRITE(N6,5399)(JUN(JSTORE(I))),ASTORE(I),CF,ZTOP(I)
 5399 FORMAT(6X,I5,13X,F8.2,7X,F8.2,10X,F6.2)
  646 CONTINUE
      NTL=NTL+NSTORE
  647 CONTINUE
C
C******** INITIALIZE NTC AND NTL
      NTC=NC
      NTL=NC
C
C******** ORIFICE DATA
C
```

```
      DO 690 I=1,60
      N=NTC+I
      READ(N5,5400) (NJUNC(N,K),K=1,2),NKLASS(N),AORIF(N),CORIF(N),
     *ZP(N,1)
 5400 FORMAT(3I5,3F5.0)
      IF(NJUNC(N,1).GE.90000) GO TO 695
  690 CONTINUE
  695 NORIF = I-1
      NTC = NTC + NORIF
      NTL = NTL + NORIF
  790 IF(NORIF) 696,696,697
  697 WRITE(N6,5420)
      DO 780 I=1,NORIF
      N = NTC - NORIF + I
      WRITE(N6,5440)(NJUNC(I,K),K=1,2),NKLASS(N),AORIF(I),
     *CORIF(I),ZP(I,1)
C
C******** CONVERT TO INTERNAL NUMBER SYSTEM
      LORIF(I)=N
      NCOND(N)=N+90000
      DEEP(N)=SQRT(4.*AORIF(N)/3.14159)
      WIDE(N)=DEEP(N)
      AFULL(N)=AORIF(N)
      RFULL(N)=DEEP(N)/4.
      CLEN=2.*DELT*SQRT(32.2*DEEP(N))
      LEN(N)=AMAX1(200.,CLEN)
      ROUGH(N)=1.49*RFULL(N)**.67/(CORIF(N)*SQRT(LEN(N)*64.4))
      NKLASS(N)=NKLASS(N)+6
C                NKLASS(N)=1, NKLASS(N)=7 - SIDE OUTLET
C                NKLASS(N)=2, NKLASS(N)=8 - BOTTOM OUTLET (SUMP)
C******** SET ZP(N,1) FOR BOTTOM OUTLET
      IF(NKLASS(N).EQ. 8) ZP(N,1)=-0.96*DEEP(N)
      DO 770 K=1,2
      DO 700 J=1,NJ
      IF(NJUNC(N,K)-JUN(J)) 700,720,700
  700 CONTINUE
      WRITE(N6,5450) NJUNC(N,K)
 5450 FORMAT('0**** ERROR **** ORIFICE JUNCTION',I6,' IS NOT CONTAINED '
     .       'IN JUNCTION DATA')
      NSTOP=NSTOP+1
  720 NJUNC(N,K)=J
C******** SET ZP(N,1) AND ZP(N,2) ELEVATIONS
      IF(K.EQ.2) GO TO 725
      ZP(N,K)=ZP(N,K)+Z(J)
      ZP(N,2) = ZP(N,1) - 0.1
  725 CONTINUE
C
C.... CHECK GROUND ELEVATION
      IF(ZP(N,K)+DEEP(N).LT. GRELEV(J)) GO TO 730
      WRITE(N6,5455) JUN(J)
 5455 FORMAT('0**** ERROR **** ORIFICE TOP LIES ABOVE GROUND ELEVATION'
     .,' AT JUNCTION',I7)
      NSTOP=NSTOP+1
C
  730 CONTINUE
      DO 740 KK=1,8
```

```
      IF(NCHAN(J,KK)) 760,760,740
  740 CONTINUE
  760 NCHAN(J,KK)=N
  770 CONTINUE
C******** CHECK GRAVITY FLOW DIRECTION
      IF(ZP(N,1) .GT. ZP(N,2)) GO TO 780
      J2=NJUNC(N,2)
      WRITE(N6,5458) JUN(J2)
 5458 FORMAT('0**** ERROR **** ORIFICE OUTLET AT JUNCTION',I7, 'IS
     1HIGHER THAN INLET')
      NSTOP=NSTOP+1
  780 CONTINUE
 5420 FORMAT('0',28(2H- ),'ORIFICE DATA',28(2H -),/,
     *14X,'JUNCTION',18X,'TYPE',20X,'AREA',18X,'DISCHARGE',
     *13X,'HEIGHT ABOVE',/,10X,'FROM',9X,'TO',39X,'(FT2)',
     *18X,'COEFF.',17X,'JUNCTION')
 5440 FORMAT(9X,I5,7X,I5,14X,I4,18X,F7.2,18X,F6.4,
     *10X,F6.3,4X,F6.3)
  696 CONTINUE
C
C******** WEIR DATA
C
C**** THIS ROUTINE HAS BEEN MODIFIED TO TRANSFER
C**** WEIR DISCHARGES FROM NODE TO NODE RATHER
C**** THAN FROM NODE TO CONDUIT
      DO 820 I=1,60
      N=NTC+I
      READ(N5,5460) (NJUNC(N,K),K=1,2),KWEIR(I),YCREST(I),YTOP(I),
     2 WLEN(I),COEF(I)
 5460 FORMAT(3I5,4F5.0)
      IF(NJUNC(N,1).GE.90000) GO TO 840
  820 CONTINUE
  840 NWEIR=I-1
      IF(NWEIR) 1040,1040,860
  860 WRITE(N6,5480)
 5480 FORMAT(//,'0',29(2H- ),'WEIR DATA',29(2H -),//,
     *8X,'JUNCTION',17X,'LINK',11X,'TYPE',11X,'CREST',11X,'WEIR',
     *11X,'WEIR',9X,'DISCHARGE',/,2X,'FROM',12X,'TO',12X,
     *'NUMBER',23X,'HEIGHT(FT)',7X,'TOP(FT)',6X,'LENGTH(FT)',
     *8X,'COEFF.')
 5487 FORMAT(1X,I5,10X,I5,12X,I5,11X,I2,12X,F5.2,10X,F5.2,
     *10X,F5.2,10X,F5.2)
      DO 1020 I=1,NWEIR
      N1=NTC+I
      LWEIR(I)=N1
      NCOND(N1)=90000+N1
      COEFS(I)=0.
      WRITE(N6,5487)(NJUNC(N1,K),K=1,2),NCOND(N1),KWEIR(I),
     *YCREST(I),YTOP(I),WLEN(I),COEF(I)
      DO 875 K=1,2
      IF(NJUNC(N1,K).EQ.0) GO TO 875
      DO 870 J=1,NJ
      IF(NJUNC(N1,K).EQ.JUN(J)) GO TO 871
  870 CONTINUE
      WRITE(N6,5490) NJUNC(N1,K)
 5490 FORMAT('0**** ERROR **** WEIR JUNCTION',I6,' IS NOT CONTAINED IN J
```

```
     2UNCTION DATA')
      NSTOP=NSTOP+1
  871 NJUNC(N1,K)=J
      DO 873 KK=1,8
      IF(NCHAN(J,KK)) 874,874,873
  873 CONTINUE
  874 NCHAN(J,KK) = N1
  875 CONTINUE
 1020 CONTINUE
      NTL=NTL+NWEIR
 1040 CONTINUE
C
C******** PUMP DATA
C
C**** NOTE -- ONLY ONE INFLUENT PIPE MAY BE CONNECTED TO A PUMP NODE
      DO 1060 I=1,20
      N=NTL+I
      READ(N5,5540) (NJUNC(N,K),K=1,2),IPTYP(I),VWELL(I),
     *(PRATE(I,K),K=1,3),(VRATE(1,K),K=1,3)
 5540 FORMAT(3I5,7F5.0)
C
C      IPTYP = 1  OFF-LINE PUMP OPERATES ON WET WELL VOLUME
C
C      IPTYP = 2  IN-LINE PUMP OPERATES ON HEAD AT JUNCTION
C
      IF(NJUNC(N,1).GE.90000) GO TO 1080
 1060 CONTINUE
 1080 NPUMP=I-1
C******** PRINT PUMP NODES
      IF(NPUMP) 1260,1260,1100
 1100 WRITE(N6,5560)
 5560 FORMAT('0',29(2H- ),'PUMP DATA',29(2H -),/,
     *4X,'JUNCTIONS',8X,'TYPE',9X,'INITIAL VOLUME',14X,
     *'PUMP RATE, CFS',15X,'VOL STAGES, FT3',11X,'WET WELL',
     */,2X,'FROM',5X,'TO',21X,'IN WELL, FT3',11X,'1',11X,'2',
     *11X,'3',10X,'1',11X,'2',11X,'VOLUME, FT3')
      DO 1120 I=1,NPUMP
      N=NTL+I
 1120 WRITE(N6,5580) I,(NJUNC(N,K),K=1,2),IPTYP(I),VWELL(I),
     *(PRATE(I,K),K=1,3),(VRATE(I,K),K=1,3)
 5580 FORMAT(1X,I5,3X,I5,6X,I5,10X,F10.0,8X,F10.0,1X,
     *F10.0,1X,F10.0,3X,F10.0,1X,F10.0,7X,F10.0)
C******** CONVERT TO INTERNAL NUMBER SYSTEM
      DO 1240 I=1,NPUMP
      N=NTL+I
      LPUMP(I)=N
      NCOND(N)=N+90000
      DO 1220 K=1,2
      DO 1140 J=1,NJ
      IF(NJUNC(N,K)-JUN(J)) 1140,1160,1140
 1140 CONTINUE
      WRITE(N6,5590) NJUNC(N,K)
 5590 FORMAT('0**** ERROR **** PUMP JUNCTION'I6,' IS NOT CONTAINED IN '
     .        'JUNCTION DATA')
      NSTOP=NSTOP+1
 1160 NJUNC(N,K)=J
```

```
      DO 1180 KK=1,8
      IF(NCHAN(J,KK)) 1200,1200,1180
 1180 CONTINUE
 1200 NCHAN(J,KK)=N
      IF(KK.LE.2) GO TO 1220
      IF(K.EQ.2) GO TO 1220
      WRITE(N6,5595) JUN(J)
 5595 FORMAT('0**** ERROR **** MORE THAN ONE PIPE IS INFLUENT TO PUMP JU
     .NCTION ',I6)
      NSTOP=NSTOP+1
 1220 CONTINUE
C******** SET JSKIP AND INFLOW INDEX FOR PUMP NODE
      JP=NJUNC(N,1)
      JSKIP(JP) = 0
      IF(IPTYP(I).EQ.2) GO TO 1235
      JSKIP(JP) = 1
      Z(JP) = -100.
 1235 CONTINUE
      JPFUL(I)=1
C
 1240 CONTINUE
      NTL=NTL+NPUMP
 1260 CONTINUE
C
C******** OUTFLOW DATA FOR OUTFALLS WITHOUT TIDE GATES
C
      DO 1280 I=1,25
      READ(N5,5600) JFREE(I)
 5600 FORMAT(I5)
      IF(JFREE(I).GE.90000) GO TO 1300
 1280 CONTINUE
 1300 NFREE=I-1
C******** PRINT OUTFLOW NODES
      IF(NFREE) 1400,1400,1320
 1320 WRITE(N6,5616)
 5616 FORMAT(//,'0',27(2H- ),'FREE OUTFALL DATA',27(2H -)//)
      WRITE(N6,5620) (JFREE(I),I=1,NFREE)
 5620 FORMAT (10X,'FREE OUTFLOW AT JUNCTIONS',4X,9I7/(39X,9I7))
C******** CONVERT TO INTERNAL NUMBER SYSTEM
 1340 DO 1390 I=1,NFREE
      DO 1360 J=1,NJ
      IF(JFREE(I)-JUN(J)) 1360,1380,1360
 1360 CONTINUE
      WRITE(N6,5630) JFREE(I)
 5630 FORMAT('0**** ERROR **** FREE OUTFALL JUNCTION',I6,' IS NOT '
     .        'CONTAINED IN JUNCTION DATA')
      NSTOP=NSTOP+1
 1380 JFREE(I)=J
      N=NTL+I
      NJUNC(N,1)=J
      NJUNC(N,2)=0
      NCHAN(J,2)=N
      NCOND(N)=N+90000
      JSKIP(J)=1
 1390 CONTINUE
      NTL=NTL+NFREE
```

```
 1400 CONTINUE
C
C******** OUTFALL DATA FOR OUTFALLS WITH TIDE GATES
C
      DO 1420 I=1,25
      READ(N5,5640) JGATE(I)
 5640 FORMAT(I5)
      IF(JGATE(I).GE.90000) GO TO 1440
 1420 CONTINUE
 1440 NGATE=I-1
C******** PRINT TIDE GATE NODES
      IF(NGATE) 1520,1520,1460
      WRITE(N6,5656)
 5656 FORMAT(//,'0',25(2H- ),'TIDE GATE OUTFALL DATA',25(2H -),//)
 1460 WRITE(N6,5660) (JGATE(I),I=1,NGATE)
 5660 FORMAT(10X,'PIPE OUTFALLS WITH TIDE GATES AT JUNCTIONS',8I7/
     *(52X,8I7))
C******** CONVERT TO INTERNAL NUMBER SYSTEM
      DO 1510 I=1,NGATE
      DO 1480 J=1,NJ
      IF(JGATE(I)-JUN(J)) 1480,1500,1480
 1480 CONTINUE
      WRITE(N6,5662) JGATE(I)
 5662 FORMAT('0**** ERROR **** TIDE GATE JUNCTION',I6,' IS NOT '
              'CONTAINED IN JUNCTION DATA')
      NSTOP=NSTOP+1
 1500 JGATE(I)=J
      N=NTL+I
      NJUNC(N,1)=J
      NJUNC(N,2)=0
      NCHAN(J,2)=N
      NCOND(N)=N+90000
      JSKIP(J)=1
 1510 CONTINUE
      NTL=NTL+NGATE
 1520 CONTINUE
C******** INTERNAL CONNECTIVITY INFORMATION
      WRITE(N6,2999)
      WRITE(N6,5060) ALPHA
      WRITE(N6,5665)
 5665 FORMAT (////'0',23(2H- ),' INTERNAL CONNECTIVITY INFORMATION',
     *23(2H -)//)
      WRITE(N6,5670)
 5670 FORMAT ('         CONDUIT     JUNCTION     JUNCTION'/)
      N1=NC+1
      DO 1525 N=N1,NTL
      J1=NJUNC(N,1)
      J2=NJUNC(N,2)
      IF(J2.GT.0) J2 = JUN(J2)
      WRITE(N6,5675) NCOND(N),JUN(J1),J2
 5675 FORMAT(4X,I11,2I13)
 1525 CONTINUE
 1527 CONTINUE
      IF(NJ.LE.NDIM) GO TO 1530
      WRITE(N6,5676)
 5676 FORMAT('0**** ERROR **** TOTAL NUMBER OF JUNCTIONS(INCLUDING WEIRS
```

```
     .) EXCEED PROGRAM DIMENSIONS, NJ=',I4)
      NSTOP=NSTOP+1
 1530 CONTINUE
      IF(NTL.LE.NDIM) GO TO 1535
      WRITE(N6,5677) NTL
 5677 FORMAT('0**** ERROR **** TOTAL NUMBER OF LINKS EXCEEDS PROGRAM DIM
     .ENSIONS,NTL=',I4)
      NSTOP=NSTOP+1
 1535 CONTINUE
C
C******** TIDAL BOUNDARY DATA
C
      READ(N5,5720) NTIDE,A1,A2,A3,A4,A5,A6,A7,W
 5720 FORMAT (I5,8F5.0)
      GO TO (1800,1790,1780,1760),NTIDE
C
C         NTIDE=1  NO CONTROL WATERSURFACE AT THE OUTFALLS
C               2  OUTFALL CONTROL WATERSURFACE AT CONSTANT ELEVATION=A1
C               3  TIDE COEFFICIENTS READ IN
C               4  COMPUTE TIDE COEFFICIENTS
C
 1760 READ(N5,5740) KO,NI,NCHTID
 5740 FORMAT (3I5)
      READ (N5,5760) (TT(I),YY(I),I=1,NI)
 5760 FORMAT (8F10.0)
      CALL TIDCF(KO,NI,NCHTID)
      GO TO 1800
 1780 WRITE(N6,5780) A1,A2,A3,A4,A5,A6,A7,W
      W=2.*3.14159/W
 5780 FORMAT('0TIDAL COEFFICIENTS.',7F10.4/'0TIDAL PERIOD (HRS).', F8.2)
      GO TO 1800
 1790 WRITE(N6,5790) A1
 5790 FORMAT('0OUTFLOW CONTROL WATER SURFACE ELEVATION IS',F7.2,' FEET')
 1800 CONTINUE
      W=W/3600.
C
C******** SET PRINT : PLOT ARRAYS IN INTERNAL NUMBER SYSTEM
      DO 1550 K=1,NQPRT
      DO 1540 N=1,NTC
      IF(NCOND(N)-CPRT(K)) 1540,1545,1540
 1540 CONTINUE
      WRITE(N6,5678) CPRT(K)
 5678 FORMAT('0**** ERROR **** CONDUIT',I6,' REQUESTED FOR PRINTOUT IS '
                'NOT CONTAINED IN CONDUIT DATA')
      NSTOP=NSTOP+1
 1545 CPRT(K)=N
 1550 CONTINUE
      IF(LPLT) 1640,1640,1560
 1560 DO 1620 K=1,LPLT
      DO 1580 N=1,NTL
      IF(NCOND(N)-KPLT(K)) 1580,1600,1580
 1580 CONTINUE
      WRITE(N6,5680) KPLT(K)
 5680 FORMAT('0**** ERROR **** CONDUIT',I6,' REQUESTED FOR PLOTTING IS '
     .          'NOT CONTAINED IN CONDUIT DATA')
      NSTOP=NSTOP+1
```

```
      GO TO 1620
 1600 KPLT(K)=N
 1620 CONTINUE
 1640 DO 1660 I=1,NHPRT
      DO 1650 J=1,NJ
      IF(JUN(J)-JPRT(I)) 1650,1655,1650
 1650 CONTINUE
      WRITE(N6,5690) JPRT(I)
 5690 FORMAT('0**** ERROR **** JUNCTION',I6,' REQUESTED FOR PRINTOUT '
     .       'IS NOT CONTAINED IN JUNCTION DATA')
      NSTOP=NSTOP+1
 1655 JPRT(I)=J
 1660 CONTINUE
      IF(NPLT.LE.0) GO TO 1740
      DO 1720 N=1,NPLT
      DO 1680 J=1,NJ
      IF (JUN(J).EQ.JPLT(N)) GO TO 1700
 1680 CONTINUE
      WRITE(N6,5700) JPLT(N)
 5700 FORMAT('0**** ERROR **** JUNCTION',I6,' REQUESTED FOR PLOTTING '
     .       'IS NOT CONTAINED IN JUNCTION DATA')
      NSTOP=NSTOP+1
      GO TO 1720
 1700 JPLT(N) = J
 1720 CONTINUE
 1740 CONTINUE
C
C******** CONDUIT INITIALIZATION
      DO 1820 N=1,NTC
 1820 ROUGH(N)=32.2*ROUGH(N)**2/2.208
 1824 CONTINUE
C
C**** READ AND WRITE INITIAL FLOWS,VELOCITIES, AND HEADS
C****    FOR ALL CONDUITS AND JUNCTIONS (INCLUDING INTERNAL).
C
      WRITE(N6,2999)
      WRITE(N6,5060) ALPHA
      WRITE(N6,11)
   11 FORMAT(1X,20(2H- ),' SUMMARY OF INITIAL HEADS, FLOWS AND
     * VELOCITIES ',22(2H- ),/)
      READ(N5,10) (Q(N),V(N),N=1,4)
      IF (Q(1).LT.99999.) GO TO 5
      DO 7 I = 1 , NTL
      Q(I)=0.
      V(I)=0.
    7 CONTINUE
      DO 8 J = 1 , NJ
      Y(J) = 0.
    8 CONTINUE
      WRITE(N6,31)
      GO TO 32
    5 CONTINUE
      IF(NTC.LT.5) GO TO 6
      READ(N5,10) (Q(N),V(N),N=5,NTL)
    6 READ(N5,10) (Y(J),J=1,NJ)
   10 FORMAT(8F10.0)
```

```
      WRITE(N6,12)
   12 FORMAT(1H0,'CONDUIT NO.',3X,'FLOW(CFS)',3X,'VELOCITY(FPS)',7X,'CON
     1DUIT NO.',3X,'FLOW(CFS)',3X,'VELOCITY(FPS)',7X,'CONDUIT NO.',3X,'F
     2LOW(CFS)',3X,'VELOCITY(FPS)'/'------------------------------------
     3----',           7X,'--------------------------------------',
     47X,'----------------------------------------'///)
      DO 15 KKK=1,NTL,3
      KSTOP=KKK+2
      IF(KSTOP.GT.NTL) KSTOP=NTL
   15 WRITE(N6,16)(NCOND(KK), Q(KK),V(KK),KK=KKK,KSTOP)
   16 FORMAT(4X,I5,8X,F5.1,9X,F5.1,14X,I5,8X,F5.1,9X,F5.1,14X,I5,8X,F5.1
     2,9X,F5.1)
      WRITE(N6,2999)
      WRITE(N6,5060) ALPHA
      WRITE(N6,20)
   20 FORMAT(1X,26(2H- ),' SUMMARY OF INITIAL DEPTHS ',26(2H- ),/)
      WRITE(N6,22)
   22 FORMAT(1H0,7X,'JUNCTION NO.',3X,'DEPTH(FT)',7X,'JUNCTION NO.',
     *3X,'DEPTH(FT)',7X,'JUNCTION NO.',3X,'DEPTH(FT)',7X,
     *'JUNCTION NO.',3X,'DEPTH(FT)',/,8X,'------------
     *-----------',3(7X,'------------------------')///)
      DO 25 KKK=1,NJ,4
      KSTOP=KKK+3
      IF(KSTOP.GT.NJ) KSTOP=NJ
   25 WRITE(N6,26)(JUN(KK),Y(KK),KK=KKK,KSTOP)
   26 FORMAT(4(11X,I5,9X,F5.1))
   31 FORMAT(///,1X,'INITIAL HEADS, FLOWS AND VELOCITIES ARE ZERO')
   32 CONTINUE
C
C******** HYDROGRAPH INPUT INITIALIZATION
      TP=TZERO
      TEO=TZERO
      DO 1840  L=1,NDIM
      ISW(L)=0
      DO 1840 K=1,2
 1840 QTAPE(L,K)=0.
      DO 1841 L=1,20
      JSW(L)=0
      DO 1841 K=1,2
 1841 QCARD(L,K)=0.
C
C******** INPUT HYDROGRAPH INFORMATION (TAPE)
C
      IF(N21) 1940,1940,1860
 1860 CONTINUE
      REWIND N21
      READ(N21) TITLE
      READ(N21)  NSTEPS,MJSW,INQUAL,D1,D2,D3
      READ(N21) (ISW(L),L=1,MJSW)
      WRITE(N6,2999)
      WRITE(N6,5060) ALPHA
C******** CONVERT TO INTERNAL NUMBERS
      DO 1920 L=1,MJSW
      DO 1880 J=1,NJ
      IF(ISW(L)-JUN(J)) 1880,1900,1880
 1880 CONTINUE
```

```
      WRITE(N6,5820) ISW(L)
 5820 FORMAT('0PROGRAM CANNOT MATCH HYDROGRAPH AT NODE',I7,' TO JUNCTION
     1 DATA')
      NSTOP=NSTOP+1
      GO TO 1920
 1900 ISW(L)=J
 1920 CONTINUE
C******** READ FIRST TWO HYDROGRAPH RECORDS
      READ(N21) T20,(QTAPE(L,1),L=1,MJSW)
      TPT = T20/3600.
      WRITE(N6,5800) TPT,MJSW
 5800 FORMAT('0****** SYSTEM INFLOWS (TAPE) AT ',F8.2,' HOURS FOR ',
     *I5,' JUNCTIONS',/,50X,'JUNCTION/INFLOW(CFS)',/)
      WRITE(N6,5830)((JUN(ISW(L)),QTAPE(L,1)),L=1,MJSW)
      READ(N21) T2,(QTAPE(L,2),L=1,MJSW)
      TPT=T2/3600.
      WRITE(N6,5810) TPT
 5810 FORMAT('0****** SYSTEM INFLOWS (TAPE) AT ',F8.2,' HOURS',
     *'      ( JUNCTION / INFLOW, CFS)',/)
      WRITE(N6,5830) ((JUN(ISW(L)),QTAPE(L,2)),L=1,MJSW)
      NINREC=2
C
C******** INPUT HYDROGRAPH DATA (CARDS)' TYPE L
C
 1940 IF(NJSW) 2040,2040,1960
 1960 READ(N5,5860) (JSW(L),L=1,NJSW)
 5860 FORMAT(16I5)
      WRITE(N6,2999)
      WRITE(N6,5060) ALPHA
C******** CONVERT TO INTERNAL NUMBERS
      DO 2020 L=1,NJSW
      DO 1980 J=1,NJ
      IF(JSW(L)-JUN(J)) 1980,2000,1980
 1980 CONTINUE
      WRITE(N6,5820) JSW(L)
      NSTOP=NSTOP+1
      GO TO 2020
 2000 JSW(L)=J
 2020 CONTINUE
C******** READ FIRST TWO HYDROGRAPH RECORDS
      READ(N5,5900) TEO,(QCARD(L,1),L=1,NJSW)
 5900 FORMAT(8F10.0)
      WRITE(N6,5829) TEO,NJSW
      WRITE(N6,5830) ((JUN(JSW(L)),QCARD(L,1)),L=1,NJSW)
 5829 FORMAT('0****** SYSTEM INFLOWS (CARDS) AT',F8.2,' HOURS',
     *' FOR',I5,' JUNCTIONS',//)
 5830 FORMAT(1X,I5,'/',F7.2,7(3X,I5,'/',F7.2))
      READ(N5,5900) TE,(QCARD(L,2),L=1,NJSW)
      WRITE(N6,5831) TE
 5831 FORMAT('0****** SYSTEM INFLOWS (CARDS) AT',F8.2,' HOURS',
     *'    ( JUNCTION / INFLOW,CFS )',/)
C
      WRITE(N6,5830)((JUN(JSW(L)),QCARD(L,2)),L=1,NJSW;
      TEO = TEO*3600.
      TE=TE*3600.
      TIMEO=TEO
```

```
 2040 CONTINUE
      IF(NSTOP.EQ.0) GO TO 2060
      WRITE(N6,5920)NSTOP
 5920 FORMAT('0******** EXECUTION TERMINATED BECAUSE OF ',
     *I2,' DATA ERROR(S) ********')
      STOP
 2060 CONTINUE
C
      RETURN
      END
```

```
      SUBROUTINE INFLOW
C
C                 THIS SUBROUTINE SELECTS THE INPUT HYDROGRAPH
C                 ORDINATE FROM TAPE AND/OR CARDS
C
        COMMON/FILES/ N5,N6,N21,N22,NPOLL
      COMMON/CONTR/ NTCYC,DELTQ,DELT,DELT2,TZERO,ALPHA(30),
     1 NJ,NC,NTC,NTL,ICYC,NJSW,MJSW,TIME,TIME2,A1,A2,A3,A4,A5,A6,A7,W
C
      COMMON/JUNC/Y(187),YT(187),NCHAN(187,8),AS(187),Z(187),QIN(187),
     1 QOU(187),QINST(187),GRELEV(187),JUN(187),ZCROWN(187),JSKIP(187)
     2 ,SUMAL(187),SUMQ(187),SUMQS(187),ASFULL(187)
C
C
C
      COMMON/HYFLOW/ ISW(187),QTAPE(187,2),JSW(65),QCARD(65,2),
     1 WATSH(187),TEO,TP,T2,TE,T20,TIMEO,NSTEPS,NINREC
C
C                             E X E C U T I O N
C
      DO 100 J=1,NJ
  100 QIN(J)=QINST(J)
C
C******** TAPE VALUES FROM WATERSHED MODEL ARE INTERPOLATED
      IF(MJSW) 280,280,120
  120 CONTINUE
      IF (TZERO-T2) 135,125,125
C******** NEW INPUT DATA REQUIRED
  125 CONTINUE
      T20=T2
      TP=T20
      DO 130 L=1,MJSW
  130 QTAPE(L,1)=QTAPE(L,2)
      IF (NINREC-NSTEPS) 132,132,131
  131 WRITE(N6,4980)
 4980 FORMAT ('0',' TZERO IS LATER IN TIME THAN LAST RECORD ON TAPE FROM
     1 WATERSHED')
      STOP
  132 CONTINUE
      READ (N21) T2,(QTAPE(L,2),L=1,MJSW)
      TPT=T2/3600.
      NINREC=NINREC+1
      WRITE(N6,4999)
 4999 FORMAT(/,1X,64(2H- ),//)
      WRITE(N6,5000)TPT
      WRITE(N6,5830)((JUN(ISW(L)),QTAPE(L,2)),L=1,MJSW)
      GO TO 120
  135 CONTINUE
      IF (TIME-T2) 220,140,140
  140 DO 160 L=1,MJSW
      J=ISW(L)
      SLOPE=(QTAPE(L,2)-QTAPE(L,1))/(T2-T20)
      Q1=QTAPE(L,1)+SLOPE*(TP-T20)
      Q2=QTAPE(L,2)
  160 QIN(J)=QIN(J)+0.5*(Q1+Q2)*(T2-TP)
      T20=T2
```

```
      TP=T20
      DO 180 L=1,MJSW
  180 QTAPE(L,1)=QTAPE(L,2)
      IF(NINREC-NSTEPS) 200,220,220
  200 READ(N21) T2,(QTAPE(L,2),L=1,MJSW)
      TPT=T2/3600.
      NINREC=NINREC+1
      WRITE(N6,4999)
      WRITE(N6,5000) TPT
 5000 FORMAT(/,'0****** SYSTEM INFLOWS (TAPE) AT',F8.2,' HOURS',
     *'      ( JUNCTION / INFLOW, CFS)',/)
      WRITE(N6,5830)((JUN(ISW(L)),QTAPE(L,2)),L=1,MJSW)
      GO TO 120
C******** NO NEW INPUT DATA REQUIRED
  220 DO 240 L=1,MJSW
      J=ISW(L)
      SLOPE=0.
      IF(T2.GT.T20) SLOPE=(QTAPE(L,2)-QTAPE(L,1))/(T2-T20)
      Q1=QTAPE(L,1)+SLOPE*(TP-T20)
      Q2=QTAPE(L,1)+SLOPE*(TIME-T20)
  240 QIN(J)=QIN(J)+0.5*(Q1+Q2)*(TIME-TP)
      TP=TIME
C
C******** CARD INPUT' VALUES ARE INTERPOLATED
  280 IF(NJSW) 420,420,300
  300 CONTINUE
      IF (TZERO-TE) 335,320,320
C******** NEW INPUT DATA REQUIRED
  320 CONTINUE
      TEO=TE
      TIMEO=TEO
      DO 325 L=1,NJSW
  325 QCARD(L,1)=QCARD(L,2)
      READ(N5,5020) TE,(QCARD(L,2),L=1,NJSW)
C
      WRITE(N6,4999)
      WRITE(N6,5831) TE
 5831 FORMAT('0****** SYSTEM INFLOWS (CARDS) AT',F8.2,' HOURS',
     *'    ( JUNCTION / INFLOW,CFS )',/)
C
      WRITE(N6,5830)((JUN(JSW(L)),QCARD(L,2)),L=1,NJSW)
 5830 FORMAT(3X,I5,'/',F7.2,7(3X,I5,'/',F7.2))
      WRITE(N6,5832)
 5832 FORMAT(//)
      TE=3600.*TE
      GO TO 300
  335 CONTINUE
      IF (TIME-TE) 380,338,338
  338 CONTINUE
      DO 340 L=1,NJSW
      J=JSW(L)
      SLOPE=(QCARD(L,2)-QCARD(L,1))/(TE-TEO)
      Q1=QCARD(L,1)+SLOPE*(TIMEO-TEO)
      Q2=QCARD(L,2)
  340 QIN(J)=QIN(J)+0.5*(Q1+Q2)*(TE-TIMEO)
      TEO=TE
```

```
      TIMEO=TEO
      DO 360 L=1,NJSW
  360 QCARD(L,1)=QCARD(L,2)
      READ(N5,5020) TE,(QCARD(L,2),L=1,NJSW)
      WRITE(N6,4999)
      WRITE(N6,5831) TE
      WRITE(N6,5830)((JUN(JSW(L)),QCARD(L,2)),L=1,NJSW)
      TE=3600.*TE
      WRITE(N6,5832)
 5020 FORMAT(8F10.0)
      GO TO 300
C******** NO NEW INPUT DATA REQUIRED
  380 DO 400 L=1,NJSW
      J=JSW(L)
      SLOPE=(QCARD(L,2)-QCARD(L,1))/(TE-TEO)
      Q1=QCARD(L,1)+SLOPE*(TIMEO-TEO)
      Q2=QCARD(L,1)+SLOPE*(TIME-TEO)
      TTT=TIME-TIMEO
      IF (TTT.GT.DELT) TTT=DELT
  400 QIN(J)=QIN(J)+0.5*(Q1+Q2)*TTT
      TIMEO=TIME
C
  420 DO 440 J=1,NJ
  440 QIN(J)=QIN(J)/DELT
      RETURN
      END
```

Subroutine TIDCF

Subroutine TIDCF is used on a one-time basis by subroutine INDATA to compute seven tide coefficients, A1 through A7, which are used by subroutine BOUND to compute the current tide elevation according to the Fourier series:

$$H_{TIDE} = A_1 + A_2 \sin \omega T + A_3 \sin 2\omega T + A_4 \sin 3\omega T + A_5 \cos \omega T + A_6 \cos 2\omega T + A_7 \cos 3\omega T \qquad (6\text{-}1)$$

where

T = current time in seconds; and

ω = angular velocity in radians per second corresponding to a 25-hour tidal period.

The coefficients A_2 through A_7 are developed by an interactive technique in TIDCF in which a sinusoidal series is fitted to the set of tidal stage-time points supplied as input data by subroutine INDATA. TIDCF is listed below.

Subroutine OUTPUT

Subroutine OUTPUT is called by program MAIN at the end of the simulation run to print and plot the hydraulic output arrays generated by the Analysis Module. Printed output includes: 1) the water depths and water surface elevations at each junction; and 2) the discharge and flow velocity in each system conduit. The plotting of junction water surface elevation and conduit discharge is carried out by a printer-plot package labelled CURVE which is called by OUTPUT after printed output is complete. A computer listing of this subroutine follows.

Subroutines CURVE, PINE, PPLOT, SCALE

The above subroutines form a general printer-plot package which is used in the Analysis Module to plot water surface elevation at selected nodes and conduit discharge in selected links. Subroutine CURVE is the executive program driving the other three subroutines of this package. CURVE is called at the conclusion of transport system simulation by OUTPUT. Listings of these four subroutines follow.

```
      SUBROUTINE TIDCF(KO,NI,NCHTID)
C
C                THIS SUBROUTINE COMPUTES SEVEN COEFFICIENTS
C                FOR A FOURIER EXPANSION OF THE DIURNAL TIDE STAGE
C
       COMMON/FILES/ N5,N6,N21,N22,NPOLL
      COMMON/CONTR/ NTCYC,DELTQ,DELT,DELT2,TZERO,ALPHA(30),
     1 NJ,NC,NTC,NTL,ICYC,NJSW,MJSW,TIME,TIME2,A1,A2,A3,A4,A5,A6,A7,W
C
      COMMON/TIDE/ YY(50) ,TT(50) ,AA(10),XX(10),SXX(10,10),SXY(10)
C
C                                       TIDE COEFFICIENTS
C                                       TIDAL CURVE FIT, 7 TERM
C                                       SINUSOIDAL EQUATION
C
      WRITE(N6,140) KO,NI,NCHTID
  140 FORMAT  (7H0 KO IS,I3,19H NUMBER OF POINTS =,I4,35H MAXIMUM NUMBER
     1 OF ITERATIONS IS 50,21H TIDE CHECK SWITCH IS,I2)
C
C                                       IF KO EQUALS ONE, PROGRAM WILL
C                                       READ FOUR POINTS OF INFORMATION
C                                       AND EXPAND THEM FOR A FULL TIDE
C
C                                       NT IS THE NUMBER OF INFORMATION
C                                       POINTS
C                                       IF NCHTID EQUALS ONE, TIDAL
C                                       INPUT-OUTPUT WILL BE PRINTED
C
C                                       MAXIT IS THE MAXIMUM NUMBER OF
C                                       ITERATIONS
C                                       DELTA IS THE ACCURACY
C                                       LIMIT IN FEET
C
      PERIOD = 25.
      MAXIT = 50
      DELTA = 0.005
      NTT=7
      W = 2.*3.14159 /PERIOD
      IF(KO.EQ.0) GO TO 225
      TT(50) =TT(1)+PERIOD
      YY(50)=YY(1)
      DO 220 I=1,4
      J=I+1
      IF (J.GT.4) J=50
      NI=NI+1
      TT(NI)=(3.*TT(I)+TT(J))/4.
      YY(NI)=0.8535*YY(I)+0.1465*YY(J)
      NI=NI+1
      TT(NI)=(TT(I)+TT(J))/2.
      YY(NI)=(YY(I)+YY(J))/2.
      NI=NI+1
      TT(NI)=(TT(I)+3.*TT(J))/4.
      YY(NI)=0.1465*YY(I)+0.8535*YY(J)
  220 CONTINUE
  225 CONTINUE
      IF (NCHTID.NE.1) GO TO 240
```

```
      WRITE(N6,146)
  146 FORMAT (29H0 NO.      TIME        VALUE  )
      WRITE(N6,148) (I,TT(I), YY(I), I=1,NI)
  148 FORMAT (I4, 2F12.3 )
  240 CONTINUE
      DO 280 J=1,NTT
      DO 260 K=1,NTT
  260 SXX(K,J) = 0.
      AA(J) = 0.
  280 SXY(J) = 0.
      NJ2 = NTT/2 + 1
      DO 360 I = 1,NI
      DO 320 J = 1,NTT
      FJ1 = FLOAT(J-1)
      FJ3 = FLOAT ( J-NJ2 )
      IF ( J.LE.NJ2 ) GO TO 300
      XX(J) = COS(FJ3*W*TT(I))
      GO TO 320
  300 XX(J) = SIN(FJ1*W*TT(I))
      IF( J.EQ.1 )XX(J) = 1.
  320 SXY(J) = SXY(J) +XX(J) *YY(I)
      DO 340 J = 1,NTT
      DO 340 K = 1,NTT
  340 SXX(K,J) = SXX(K,J) +XX(K) *XX(J)
  360 CONTINUE
      IT = 0
  380 IT = IT + 1
      DELMAX = 0.
      DO 420 K = 1,NTT
      SUM = 0.
      DO 400 J = 1,NTT
      IF (J.EQ.K) GO TO 400
      SUM = SUM -AA(J)*SXX(K,J)
  400 CONTINUE
      SUM = (SUM+SXY(K))/SXX(K,K)
      DEL = ABS(SUM-AA(K))
      IF (DEL.GT.DELMAX ) DELMAX = DEL
  420 AA(K) = SUM
      IF ( IT.GE.MAXIT ) GO TO 440
      IF (DELMAX.GT.DELTA ) GO TO 380
      GO TO 460
  440 WRITE(N6,150)
  150 FORMAT ('  CANNOT REACH DESIRED DELTA, INCREASE EITHER NI OR DELTA
     1 AND TRY AGAIN')
      STOP
  460 CONTINUE
      A1 = AA(1)
      A2 = AA(2)
      A3 = AA(3)
      A4 = AA(4)
      A5 = AA(5)
      A6 = AA(6)
      A7 = AA(7)
      IF (NCHTID.NE.1) GO TO 540
      WRITE(N6,152)
  152 FORMAT (46H0      TIME    OBSERVED    COMPUTED      DIFF  )
```

```
      RES = 0.
      DO 520 I = 1,NI
      SUM = 0.
      DO 500 J = 2,NTT
      FJ1 = FLOAT ( J-1 )
      FJ3 = FLOAT ( J-NJ2 )
      IF ( J.LE.NJ2 ) GO TO 480
      SUM = SUM +AA(J) *COS(FJ3*W*TT(I))
      GO TO 500
  480 SUM = SUM +AA(J) *SIN(FJ1*W*TT(I))
  500 CONTINUE
      SUM = SUM +AA(1)
      DIFF = SUM -YY(I)
      RES = RES + ABS(DIFF)
  520 WRITE(N6,154) TT(I),YY(I),SUM,DIFF
  154 FORMAT ( 4F12.4 )
      WRITE(N6,156) RES
  156 FORMAT (6HOTOTAL , 30X, F12.4 )
  540 CONTINUE
C
C                                       CONSTANTS FOR INPUT WAVE FORM
C
      WRITE(N6,158)A1,A2,A3,A4,A5,A6,A7
  158 FORMAT(///46H COEFFICIENTS FOR TIDAL STAGE ARE                //85H
     1     A1         A2         A3         A4         A5         A6
     2A7                //7F10.3,F12.2///31H WHERE THE WAVEFORM IS GIVE
     3N BY//92H H(J) = A1 + A2*SIN(WT) + A3*SIN(2WT) + A4*SIN(3WT) + A5*
     4COS(WT) + A6*COS(2WT) + A7*COS(3WT))
      RETURN
      END
```

```
      SUBROUTINE OUTPUT
C
C                 THIS SUBROUTINE PRINTS OUTPUT
C                 * CONTROLS THE PRINTER PLOT ROUTINES
C
       COMMON/FILES/ N5,N6,N21,N22,NPOLL
       COMMON/CONTR/NTCYC,DELTQ,DELT,DELT2,TZERO,ALPHA(30),
     1 NJ,NC,NTC,NTL,ICYC,NJSW,MJSW,TIME,TIME2,A1,A2,A3,A4,A5,A6,A7,W
C
      COMMON/JUNC/Y(187),YT(187),NCHAN(187,8),AS(187),Z(187),QIN(187),
     1 QOU(187),QINST(187),GRELEV(187),JUN(187),ZCROWN(187),JSKIP(187)
     2 ,SUMAL(187),SUMQ(187),SUMQS(187),ASFULL(187)
C
      COMMON/PIPE/LEN(187),NJUNC(187,2),AFULL(187),AT(187),
     1 Q(187),V(187),VT(187),DEEP(187),A(187),WIDE(187),RFULL(187),
     2 NKLASS(187),ZP(187,2),QT(187),QO(187),H(187,2),NCOND(187),
     3 ROUGH(187)
      REAL LEN
C
      COMMON/STORE/ NSTORE,JSTORE(20),ZTOP(20),ASTORE(20)
C
      COMMON/OUT/ NPRT,IPRT,NHPRT,JPRT(20),PRTH(100,20),PRGEL(20),
     1 NQPRT,CPRT(20),PRTV(100,20),PRTQ(100,20),IDUM(12),ICOL(10),
     2 LTIME,NPLT,JPLT(20),YPLT(102,20),LPLT,KPLT(20),QPLT(102,20),
     3 TPLT(102),NPTOT,NSTART,INTER,PRTY(100,20)
      COMMON/ELEV/ ZINVRT,ZCRN,ZGRND,IPLT
      INTEGER CPRT
C
      COMMON/LAB/TITLE(40),XLAB(11),YLAB(6),HORIZ(5),VERT(6)
      COMMON/STATS/VMAXX(187),QMAXX(187),DEPMAX(187),IVHR(187),
     2IVMIN(187),IQHR(187),IQMIN(187),IDHR(187),IDMIN(187),SURLEN(187),
     3SUMQIN,VLEFT
C
      DIMENSION VERTQ(6)
      DATA VERTQ/4HCOND,4HUIT ,4H FLO,4HW   ,4HIN  ,4HCFS /
C
C                            E X E C U T I O N
C******** PRINT CONTINUITY SUMMARY
C
C
      WRITE(N6,5002)
 5002 FORMAT(////,' ',23(2H- ),' CONTINUITY BALANCE AT END OF RUN ',
     *23(2H- ),/)
 5001 FORMAT(' TOTAL SYSTEM INFLOW VOLUME =',F12.0,' CU FT',/)
      WRITE(N6,5001) SUMQIN
      WRITE(N6,5004)
 5004 FORMAT(' JUNCTION OUTFLOWS AND',/,' STREET FLOODING',/)
      WRITE(N6,5005)
 5005 FORMAT(4X,'JUNCTION',2X,'OUTFLOW, FT3',/)
      DO 119 J=1,NJ
      IF(QOU(J).GT.0.) WRITE(N6,5003) JUN(J),QOU(J)
 5003 FORMAT(7X,I5,2X,F12.0)
      SUMOUT = SUMOUT + QOU(J)
  119 CONTINUE
      WRITE(N6,5007)
 5007 FORMAT(15X,7(2H--))
```

```
      WRITE(N6,5008) SUMOUT
 5008 FORMAT(13X,'TOTAL',11X,F12.0,' CU FT',/)
      WRITE(N6,5009) VLEFT
 5009 FORMAT(' VOLUME LEFT IN SYSTEM =',5X,F12.0,' CU FT',/)
      PCTERR = ((SUMQIN-SUMOUT-VLEFT)/SUMQIN)*100.
      WRITE(N6,5006) PCTERR
 5006 FORMAT(' ERROR IN CONTINUITY, PERCENT =',F6.2)
C******** PRINT H.G.L. AND WATER DEPTH AT NODES
C
      NSTART=NSTART-LTIME*INTER
      TIMEO=TZERO+FLOAT(NSTART)*DELT
      DO 100 I=1,NHPRT
      MJPRT=JPRT(I)
      JPRT(I)=JUN(MJPRT)
  100 PRGEL(I)=GRELEV(MJPRT)
 5000 FORMAT(' ',15A4/' ',15A4//)
      DO 120 I=1,NHPRT,6
      WRITE(N6,2999)
2999  FORMAT('1',64(2H--)/' ','FEDERAL HIGHWAY ADMINISTRATION',14X,40H**
     2** URBAN HIGHWAY DRAINAGE PROGRAM ****,8X,'WATER RESOURCES DIVISIO
     3N'/' ','DEPARTMENT OF TRANSPORTATION',16X,4H****,32X,4H****,8X,
     4'CAMP DRESSER & MCKEE INC.'/' ','WASHINGTON, D.C.',28X,4H
     5****,6X,'   ANALYSIS MODULE  ',6X,4H****,8X,'ANNANDALE, VIRGINIA
     6')
      WRITE(N6,5000) ALPHA
      WRITE(N6,5020)
 5020 FORMAT (125H0  * * * * * * * * * * * * * * * * * * * * *   T I M E
     1H I S T O R Y  O F  H. G. L.    * * * * * * * * * * * * * * * * *
     2* * *)
      WRITE(N6,5030)
 5030 FORMAT (56X,' (VALUES IN FEET)')
      IT=I+5
      IF(IT.GT.NHPRT) IT=NHPRT
      WRITE(N6,5040) (JPRT(L),L=I,IT)
 5040 FORMAT (1H0, 8X,6(7X,'JUNCTION',I5))
      WRITE(N6,5060) (PRGEL(L),L=I,IT)
 5060 FORMAT('  TIME', 2X,6(8X,' GRND',F7.2),/,' HR . MIN',6(7X,'ELEV
     1 DEPTH'),/)
      LT=MIN0(I+5,NHPRT)
      DO 120 L=1,LTIME
      TIME=(TIMEO+FLOAT((L-1)*INTER)*DELT)/3600.
      LTIMEH=IFIX (TIME)
      LTIMEM=IFIX((TIME-FLOAT(LTIMEH))*60.0+0.5)
  120 WRITE(N6,5080) LTIMEH,LTIMEM,(PRTH(L,K),PRTY(L,K),K=I,LT)
 5080 FORMAT (' ',I3,'.',I2,2X,6(F12.2,F8.2))
C
C********  COMPUTE AND PRINT SUMMARY STATISTICS FOR JUNCTIONS
C
      DO 700 J=1,NJ
      IF(J.EQ.1.OR.(J/39*39).EQ.J) GO TO 701
      GO TO 702
  701 WRITE(N6,2999)
      WRITE(N6,5000) ALPHA
      WRITE(N6,750)
  750 FORMAT(//' ',16(2H' ),2X,'S U M M A R Y  S T A T I S T I C S  F O
     2R  J U N C T I O N S',2X,16(2H '')//)
```

```
      WRITE(N6,751)
  751 FORMAT(' ',36X,'UPPERMOST',9X,'MAXIMUM',5X,'TIME',11X,'FEET OF',
     211X,'FEET MAX.',11X,'LENGTH'/' ',20X,'GROUND',9X,'PIPE CROWN',8X,
     3'COMPUTED',6X,'OF',11X,'SURCHARGE',10X,'DEPTH IS',14X,'OF'/' ',
     42X,'JUNCTION',8X,'ELEVATION',9X,'ELEVATION',10X,'DEPTH',3X,
     5'OCCURENCE',9X,'AT MAX.',9X,'BELOW GROUND',8X,'SURCHARGE'/' ',
     63X,'NUMBER',12X,'(FT)',2(13X,'(FT)'),4X,'HR.',2X,'MIN.',10X,
     7'DEPTH',12X,'ELEVATION',11X,'(MIN)'/' ',2X,8('-'),8X,9('-'),8X,
     810('-'),8X,19('-'),8X,9('-'),8X,12('-'),8X,9('-')/)
C
C******** COMPUTE FEET MAXIMUM DEPTH IS BELOW GROUND ELEVATION
  702 FTBLG=GRELEV(J)-(DEPMAX(J)+Z(J))
      IF(FTBLG.LE.0.0)FTBLG=0.
C
C******** COMPUTE FEET OF SURCHARGE AT MAXIMUM DEPTH
      SURMAX=DEPMAX(J)+Z(J)-ZCROWN(J)
      IF(SURMAX.LE.0.0) SURMAX=0.0
C
C******** PRINT JUNCTION STATISTICS
      WRITE(N6,752)  JUN(J),GRELEV(J),ZCROWN(J),DEPMAX(J),IDHR(J),
     2IDMIN(J),SURMAX,FTBLG,SURLEN(J)
  752 FORMAT(' ',4X,I5,10X,F7.2,11X,F7.2,10X,F6.2,3X,I3,3X,I2,11X,F5.2,
     214X,F5.2,13X,F5.1)
  700 CONTINUE
C
C******** PRINT FLOWS * VELOCITIES IN PIPES
C
      DO 140 I=1,NQPRT
      L=CPRT(I)
  140 CPRT(I)=NCOND(L)
      DO 160 I=1,NQPRT,6
      WRITE(N6,2999)
      WRITE(N6,5000) ALPHA
      WRITE(N6,5100)
 5100 FORMAT (125H0  * * * * * * * * * * * * * * * *  T I M E  H I S T O R
     1 Y  O F  F L O W  A N D  V E L O C I T Y  * * * * * * * * * * * *
     1* * *  /,49X,'Q(CFS), VEL(FPS)')
      IT=I+5
      IF(IT.GT.NQPRT) IT=NQPRT
      WRITE(N6,5120) (CPRT(L),L=I,IT)

 5120 FORMAT (1H0,'  TIME',6(4X,'CONDUIT',I5,4X),/
     1 ' HR . MIN',6(2X,'FLOW   VEL        '))
      LT=MIN0(I+5,NQPRT)
      DO 160 L=1,LTIME
      TIME=(TIME0+FLOAT((L-1)*INTER)*DELT)/3600.
      LTIMEH=IFIX (TIME)
      LTIMEM=IFIX((TIME-FLOAT(LTIMEH))*60.0+0.5)
  160 WRITE(N6,5140) LTIMEH,LTIMEM,(PRTQ(L,K),PRTV(L,K),K=I,LT)
 5140 FORMAT (1H ,I3,'.',I2,2X,6(F7.2,F5.1,8X))
C
C******** COMPUTE AND PRINT SUMMARY STATISTICS FOR CONDUITS
C
      DO 900 N=1,NC
      IF(N.EQ.1.OR.(N/39*39).EQ.N) GO TO 901
      GO TO 902
```

```
  901 WRITE(N6,2999)
      WRITE(N6,5000) ALPHA
      WRITE(N6,800)
  800 FORMAT(//' ',16(2H' ),1H',2X,'S U M M A R Y  S T A T I S T I C S
     2F O R  C O N D U I T S',2X,1H',16(2H ')//)
      WRITE(N6,801)
  801 FORMAT(' ',35X,'CONDUIT',5X,'MAXIMUM',5X,'TIME',7X,'MAXIMUM',
     25X,'TIME',6X,'RATIO OF',6X,'MAXIMUM DEPTH ABOVE'/' ',12X,
     32('DESIGN',5X),'VERTICAL',4X,'COMPUTED',6X,'OF',7X,'COMPUTED',
     46X,'OF',8X,'MAX. TO',4X,'INVERT AT CONDUIT ENDS'/' ',1X,'CONDUIT',
     55X,'FLOW',5X,'VELOCITY',6X,'DEPTH',7X,'FLOW',4X,'OCCURENCE',4X,
     6'VELOCITY',2X,'OCCURENCE',5X,'DESIGN',5X,'UPSTREAM',4X,
     7'DOWNSTREAM'/' ',2X,'NUMBER',5X,'(CFS)',6X,'(FPS)',7X,'(IN)',8X,
     8'(CFS)',3X,'HR.',2X,'MIN.',6X,'(FPS)',3X,'HR.',2X,'MIN.',6X,
     9'FLOW',8X,'(FT)',9X,'(FT)'/' ',1X,7('-'),4X,6('-'),2(4X,8('-')),
     12(4X,19('-')),4X,8('-'),4X,22('-')/)
C
C********  COMPUTE DESIGN VELOCITY AND FLOW IN CONDUIT
  902 NL=NJUNC(N,1)
      NH=NJUNC(N,2)
      SLOPE=(ZP(N,1)-ZP(N,2))/LEN(N)
      VDSGN=SQRT(32.2*SLOPE/ROUGH(N))*RFULL(N)**0.6666667
      QDSGN=AFULL(N)*VDSGN
C
C********  COMPUTE RATIO OF MAX TO DESIGN FLOW IN CONDUIT
      QRATIO=0.
      IF(QDSGN.GT.0.) QRATIO=QMAXX(N)/QDSGN
C
C********  COMPUTE MAX WATER DEPTH ABOVE CONDUIT INVERT AT BOTH ENDS
      DMAXNL=DEPMAX(NL)-(ZP(N,1)-Z(NL))
      DMAXNH=DEPMAX(NH)-(ZP(N,2)-Z(NH))
      VHGHT=DEEP(N)*12.0
C
C********  PRINT CONDUIT STATISTICS
      WRITE(N6,802) NCOND(N),QDSGN,VDSGN,VHGHT,QMAXX(N),IQHR(N),
     2IQMIN(N),VMAXX(N),IVHR(N),IVMIN(N),QRATIO,DMAXNL,DMAXNH
  802 FORMAT(' ',2X,I5,2(5X,F6.1),7X,F5.1,2(6X,F6.1,3X,I3,3X,I2),6X,
     2F6.1,7X,F5.2,8X,F5.2)
  900 CONTINUE
C
C'''''''' PRINTER PLOT PACKAGE
      IF(NPLT) 220,220,180
  180 DO 200 N=1,NPLT
      IPLT=1
      J=JPLT(N)
      ZINVRT=Z(J)
      ZCRN=ZCROWN(J)
      ZGRND=GRELEV(J)
      NJUN=JUN(J)
      CALL CURVE(TPLT,YPLT(1,N),NPTOT,1,NJUN)
  200 WRITE(N6,5160) NJUN
 5160 FORMAT(100X,'JUNCTION NUMBER',I7)
  220 IF(LPLT) 300,300,240
  240 DO 260 L=1,6
  260 VERT(L)=VERTQ(L)
      DO 280 N=1,LPLT
```

```
      IPLT=2
      L=KPLT(N)
      NKON=NCOND(L)
      CALL CURVE(TPLT,QPLT(1,N),NPTOT,1,NKON)
  280 WRITE(N6,5180) NKON
 5180 FORMAT(100X,'CONDUIT NUMBER',I7)
  300 RETURN
      END
```

```
      SUBROUTINE CURVE(X,Y,NPT,NCV,NPLOT)
        COMMON/FILES/ N5,N6,N21,N22,NPOLL
      DIMENSION X(202,5),Y(202,5),NPT(5)
     1,DUMX(4),DUMY(4)
      COMMON/LAB/ALPHA(40),XLAB(11),YLAB(6),HORIZ(5),VERT(6)
C
C                                       SET UP X AND Y SCALES
C
      XMAX = -1.0E30
      XMIN = 1.0E30
      YMAX = -1.0E30
      YMIN = 1.0E30
      DO 100 K = 1, NCV
      N = NPT(K)
      DO 100 J = 1, N
      IF( X(J,K) .GT. XMAX ) XMAX = X(J,K)
      IF( X(J,K) .LT. XMIN ) XMIN = X(J,K)
      IF( Y(J,K) .GT. YMAX ) YMAX = Y(J,K)
      IF( Y(J,K) .LT. YMIN ) YMIN = Y(J,K)
  100 CONTINUE
      DUMX(1) = XMIN
      DUMX(2) = XMAX
      CALL SCALE(DUMX,10.0,2,1)
      DUMY(1) = YMIN
      DUMY(2) = YMAX
      CALL SCALE (DUMY,4.0,2,1)
      DO 120 K = 1, NCV
      N = NPT(K)
      X(N+1,K) = DUMX(3)
      X(N+2,K) = DUMX(4)
      Y(N+1,K) = DUMY(3)
      Y(N+2,K) = DUMY(4)
  120 CONTINUE
C
C                                       FORM X LABELS AND FACTORS
C
      XMIN= DUMX(3)
      DELTX= DUMX(4)
      XLAB(1)=XMIN
      DO 140 I=1,10
  140 XLAB(I+1)=XLAB(I)+DELTX
      XSCAL=100./(XLAB(11)-XMIN)
C
C                                       FORM Y LABELS AND FACTORS
C
      YMIN= DUMY(3)
      DELTY= DUMY(4)
      YLAB(5)=YMIN
      DO 160 I=1,4
  160 YLAB(5-I)=YLAB(6-I)+DELTY
      YSCAL=40./(YLAB(1)-YMIN)
C
C                                       INITIALIZE PLOT OUTLINE
C
      NCD=100
      CALL PPLOT(0,0,NCD,NPLOT)
```

```
      K = 1
C
C                                   DRAW IN EACH CURVE
C
      DO 240 L=1,NCV
       IF(NPT(L).EQ.0) GO TO 220
C
C                                   JOINING XO YO AND XT YT
C
      XO=XSCAL*(X(1,L)-XMIN)
      YO=YSCAL*(Y(1,L)-YMIN)
      NPOINT = NPT(L)
      DO 180 N = 2,NPOINT
      XT = XSCAL*(X(N,L) - XMIN)
      YT = YSCAL*(Y(N,L) - YMIN)
      CALL PINE(XO,YO,XT,YT,K,NPLOT)
      XO = XT
      YO = YT
  180 CONTINUE
  200 CONTINUE
  220 K = K + 1
  240 CONTINUE
C
C                                   OUTPUT FINAL PLOT
C
      NC=99
      CALL PPLOT(0,0,NC,NPLOT)
      RETURN
      END
```

```
      SUBROUTINE PINE(X1,Y1,X2,Y2,NSYM,NCT)
        COMMON/FILES/ N5,N6,N21,N22,NPOLL
      COMMON/CONTR/ NTCYC,DELTQ,DELT,DELT2,TZERO,ALPHA(30),
     1 NJ,NC,NTC,NTL,ICYC,NJSW,MJSW,TIME,TIME2,A1,A2,A3,A4,A5,A6,A7,W
      COMMON/ELEV/ ZINVRT,ZCRN,ZGRND,IFLT
C
      COMMON/LAB/TITLE(40),XLAB(11),YLAB(6),HORIZ(5),VERT(6)
C
      AXA=X1
      AXB=X2
      AYA=Y1
      AYB=Y2
      IF((AXB.EQ.AXA).AND.(AYB.EQ.AYA)) RETURN
      N=1
      IF(ABS(AXB-AXA).LT.ABS(AYB-AYA)) GO TO 160
C
C     SET PARAMETERS FOR X DIRECTION
C
      IF(AXB.GT.AXA) GO TO 100
      AXA=X2
      AXB=X1
      AYA=Y2
      AYB=Y1
  100 CONTINUE
      IXA=AXA+.5
      IXB=AXB+.5
      IYA=AYA+.5
      IYB=AYB+.5
  120 CONTINUE
      IF(IXA.LT.0.OR.IXA.GT.100) GO TO 140
      IF(IYA.LT.0.OR.IYA.GT.40) GO TO 140
      CALL PPLOT(IXA,IYA,NSYM,NCT)
  140 CONTINUE
      IXA=IXA+1
      YA=(N*(AYB-AYA))/(AXB-AXA)
      IYA=AYA+YA+0.5
      N=N+1
      IF(IXA.LE.IXB) GO TO 120
      GO TO 260
C
C     SET PARAMETERS FOR Y DIRECTION
C
  160 CONTINUE
      IF(AYB.GT.AYA)   GO TO 180
      AYB=Y1
      AYA=Y2
      AXB=X1
      AXA=X2
  180 CONTINUE
      IXA=AXA+.5
      IXB=AXB+.5
      IYA=AYA+.5
      IYB=AYB+.5
  200 CONTINUE
      IF(IXA.LT.0.OR.IXA.GT.100) GO TO 220
      IF(IYA.LT.0.OR.IYA.GT.40) GO TO 220
```

```
      CALL PPLOT(IXA,IYA,NSYM,NCT)
  220 CONTINUE
      IYA=IYA+1
      XA=(N*(AXB-AXA))/(AYB-AYA)
      IXA=XA+AXA+0.5
      N=N+1
      IF(IYA-IYB) 200,240,260
  240 IXA = IXB
      GO TO 200
  260 RETURN
      END
```

```
      SUBROUTINE PPLOT(IX,IY,K,NCT)
      DIMENSION A(51,101),SYM(9)
C
        COMMON/FILES/ N5,N6,N21,N22,NPOLL
      COMMON/CONTR/ NTCYC,DELTQ,DELT,DELT2,TZERO,ALPHA(30),
     1 NJ,NC,NTC,NTL,ICYC,NJSW,MJSW,TIME,TIME2,A1,A2,A3,A4,A5,A6,A7,W
C
      COMMON/ELEV/ ZINVRT,ZCRN,ZGRND,IPLT
C
      COMMON/LAB/TITLE(40),XLAB(11),YLAB(6),HORIZ(5),VERT(6)
C
      DATA SYM / 4H****,4H++++, 4H'''', 4HXXXX, 4H...., 4H2222,
     1 4H    , 4HIIII, 4H---- /
      IF(K-99) 100,120,260
  100 A(41-IY,IX+1)=SYM(K)
      RETURN
  120 CONTINUE
      I=0
      J2=1
      WRITE(N6,2999)
 2999 FORMAT('1',64(2H--)/' ','FEDERAL HIGHWAY ADMINISTRATION',14X,40H**
     2** URBAN HIGHWAY DRAINAGE PROGRAM ****,8X,'WATER RESOURCES DIVISIO
     3N'/' ','DEPARTMENT OF TRANSPORTATION',16X,4H****,32X,4H****,8X,
     4'CAMP DRESSER & MCKEE INC.'/' ','WASHINGTON, D.C.',28X,4H
     5****,6X,'   ANALYSIS MODULE  ',6X,4H****,8X,'ANNANDALE, VIRGINIA
     6')
      WRITE(N6,1300) ALPHA
      DO 220 II=1,5
      I=I+1
      IF(IPLT.EQ.2)GO TO 130
  125 IF (II.NE.1) GO TO 130
      WRITE(N6,1050) YLAB(II),A(1,1),ZINVRT,(A(1,J),J=29,101)
      WRITE(N6,1051) A(2,1),ZCRN,(A(2,J), J=29,101)
      WRITE(N6,1052) A(3,1),ZGRND,(A(3,J),J=29,101)
      I=3
      J2=3
      GO TO 135
  130 WRITE(N6,1100) YLAB(II),(A(I,J),J=1,101)
      IF(II.EQ.5) GO TO 240
  135 DO 200 JJ=J2,9
      I=I+1
      IF(I.NE.28) GO TO 140
      WRITE(N6,1500) VERT(5),VERT(6),(A(I,J),J=1,101)
      GO TO 200
  140 IF(I.NE.24) GO TO 160
      WRITE(N6,1500) VERT(1),VERT(2),(A(I,J),J=1,101)
      GO TO 200
  160 IF(I.NE.26) GO TO 180
      WRITE(N6,1500) VERT(3),VERT(4),(A(I,J),J=1,101)
      GO TO 200
  180 WRITE(N6,1000) (A(I,J),J=1,101)
  200 CONTINUE
      J2=1
  220 CONTINUE
  240 CONTINUE
      WRITE(N6,1200) XLAB
```

```
      WRITE(N6,1400) HORIZ
 1000 FORMAT(18X,101A1)
 1050 FORMAT (F17.3,1X,A1,2X,'INVERT ELEV-',F8.2,' FEET',73A1)
 1051 FORMAT (18X,A1,2X,' CROWN ELEV-',F8.2,' FEET',73A1)
 1052 FORMAT (18X,A1,2X,'GROUND ELEV-',F8.2,' FEET',73A1)
 1100 FORMAT(F17.3,1X,101A1)
 1200 FORMAT(F20.1,10F10.1)
 1300 FORMAT(' ',15A4/' ',15A4//)
 1400 FORMAT(/45X,20A4)
 1500 FORMAT(3X,2A4,7X,101A1)
  260 DO 300 I=1,40
      DO 280 J=1,101
  280 A(I,J)=SYM(7)
      A(I,1)=SYM(8)
  300 CONTINUE
      DO 320 J=1,101
  320 A(41,J)=SYM(9)
      DO 340  I=1,101,10
  340 A(41,I)=SYM(8)
      DO 360 I=11,31,10
      A(I,1)=SYM(9)
  360 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SCALE (ARRAY,AXLEN,NPTS,INC)
        COMMON/FILES/ N5,N6,N21,N22,NPOLL
      DIMENSION ARRAY(NPTS),INT(5)
      DATA INT /2,4,5,8,10/
      INCT=IABS(INC)
C
C                                       SCAN FOR MAX AND MIN
C
      AMAX=ARRAY(1)
      AMIN=ARRAY(1)
      DO 100 N=1,NPTS,INCT
      IF(AMAX.LT.ARRAY(N)) AMAX=ARRAY(N)
      IF(AMIN.GT.ARRAY(N)) AMIN=ARRAY(N)
  100 CONTINUE
      IF( AMAX - AMIN ) 180,120,180
C
C                                       RESET MAX AND MIN FOR ZERO RANGE
C
  120 IF( AMIN ) 160,320,140
  140 AMIN = 0.0
      AMAX = 2.0 * AMAX
      GO TO 180
  160 AMAX = 0.0
      AMIN = 2.0 * AMIN
  180 CONTINUE
C
C                                       COMPUTE UNITS/INCH
C
      RATE=(AMAX-AMIN)/AXLEN
C
C                                                 SCALE INTERVAL TO
C                                                 LESS THAN 10
      A=ALOG10(RATE)
      N=A
      IF(A.LT.0) N=A-0.9999
      RATE=RATE/(10.**N)
      L=RATE+1.00
C
C                                       FIND NEXT HIGHER INTERVAL
C
  200 DO 220 I=1,5
      IF(L-INT(I)) 240,240,220
  220 CONTINUE
C
C                                       L IS NEXT HIGHER INTERVAL
C                                       RANGE IS SCALED BACK TO FULL SET
C
  240 L=INT(I)
      RANGE=FLOAT(L)*10.**N
      IF(INC.LT.0) GO TO 300
C
C                                       SET UP POSITIVE STEPS
C
      K=AMIN/RANGE
      IF(AMIN.LT.0.) K=K-1
C
```

```
C                                   CHECK FOR MAX VALUE IN RANGE
C
      IF(AMAX.GT.(K+AXLEN)*RANGE) GO TO 260
      I=NPTS*INCT+1
      ARRAY(I)=K*RANGE
      I=I+INCT
      ARRAY(I)=RANGE
      RETURN
C
C                                   IF OUTSIDE RANGE RESET L AND N
C
  260 L=L+1
      IF(L.LT.11) GO TO 200
      L=2
      N=N+1
  280 GO TO 200
C
C                                   SET UP NEGATIVE STEPS
C
  300 K=AMAX/RANGE
      IF(AMAX.GT.0.) K=K+1
      IF(AMIN.LT.(K+AXLEN)*RANGE) GO TO 260
      I=INCT*NPTS+1
      ARRAY(I)=K*RANGE
      I=I+INCT
      ARRAY(I)=-RANGE
      RETURN
  320 WRITE(N6,1000)
 1000 FORMAT( // 10X, 'RANGE AND SCALE ARE ZERO ON PLOT ATTEMPT'  )
      RETURN
      END
```

Variables In Common

The Analysis Module uses the following 17 common blocks in various locations throughout the program:

- BD
- BND
- CONTR
- ELEV
- HLOS
- HYFLOW
- JUNC
- LAB
- LOSS
- ORF
- OUT
- PIPE
- PUMP
- QUAL
- TIDE
- TRNQAL
- WEIR

Table 4-3 defines the variables contained in each of these common blocks and indicates the subroutines containing each common block.

TABLE 4-3

DEFINITION OF VARIABLES IN COMMON

Variable Name	Description	Units
	COMMON/BD/	
	This common is used in the following subroutines BLOCK DATA DEPTH HYDRAD INDATA	
ANORM	Matrix of normalized wet cross-sectional area of conduit, based on shape and depth	
HRNORM	Matrix of normalized hydraulic radius of conduit, based on shape and depth	
TWNORM	Matrix of normalized conduit width at flow line, based on shape and depth	
	COMMON/BND/	
	This common is used by the following subroutines BOUND INDATA	
JFREE	Node for free outfall	None
JGATE	Node for non-weir tide gate	None
JTIDE	Not used at this time	None
NFREE	Number of free outfalls	None
NGATE	Number of non-weir tide gates	None
NTIDE	Indicator for outfall tide level control 1. no water surface at outfall 2. outfall control water surface at constant elevation, A1 3. tide coefficient provided 4. program will compute tide coefficients	None

TABLE 4-3
(continued)

Variable Name	Description	Units
	COMMON/CONTR/	
	This common is used in the following subroutines BOUND INDATA INFLOW MAIN OUTPUT PPLOT TIDCF	
ALPHA	Title for printing	None
A1	Coefficients of the seven term equation for tidal input	Feet
A2		None
A3		None
A4		None
A5		None
A6		None
A7		None
DELTQ	Not used at this time	
DELT	Time interval of integration	Seconds
DELT2	One-half of DELT	Seconds
ICYC	Internal cycle counter	None
MJSW	Number of tape input hydrographs	None
NC	Number of conduits	None
NJ	Number of nodes	None
NJSW	Number of nodes for hydrograph input via cards	None

TABLE 4-3
(continued)

Variable Name	Description	Units
NTC	Number of nodal links including internal links	None
NTCYC	Number of integration cycles	None
N5	Input unit number	None
N6	Output unit number	None
N21	Unit number for input tape from RUNOFF BLOCK	None
TIME	Time counter for hydrograph input	Seconds
TIME2	TIME - DELT2	Seconds
TZERO	Zero time for the simulation	Hours/Seconds
W	Fundamental frequency of daily tidal cycle	rad per sec
	COMMON/ELEV/	
	This common is used in the following subroutines OUTPUT PPLOT	
IPLT	Plot control integer	None
ZCRN	Plot variable, highest crown elevation at a node	Feet
ZGRND	Plot variable, ground elevation	Feet
ZINVRT	Plot variable, node invert elevation	Feet
	COMMON/HLOS/	
	This common is used in the following subroutines MAIN OUTPUT	
PRTL1	Storage matrix for head losses for printing purposes	None
PRTL2	Storage matrix for head losses for printing purposes	None

TABLE 4-3
(continued)

Variable Name	Description	Units
	COMMON/HYFLOW/	
	This common is used in the following subroutines INDATA INFLOW	
ISW	Hydrograph input node number from tape	None
JSW	Hydrograph input node number from cards	None
NINREC	Counter for hydrograph input from tape	None
NSTEPS	Number of input records on input hydrograph file	None
QCARD	Rate of inflow, from cards	cfs
QTAPE	Rate of inflow, from tape	cfs
TE	Time of inflow for card input	Hours/Seconds
TEO	Previous value of TE	Hours/Seconds
TIMEO	TEO	Seconds
TP	TZERO	Seconds
T2	Time of inflow for tape input	Seconds
T2O	Previous value of T2	Seconds
WATSH	Not used at this time	None

TABLE 4-3
(continued)

Variable Name	Description	Units
	COMMON/JUNC/	
	This common is used in the following subroutines BOUND HEAD INDATA INFLOW MAIN OUTPUT	
AS	Surface area of a node	Square Feet
GRELEV	Ground elevation at a node	Feet
JSKIP	Internal integer control, to skip nodal head computation	None
JUN	External node number	None
NCHAN	Conduits connecting to a node	None
QIN	Flow into a node from an outside source	cfs
QINST	Dry weather flow into a node from an outside source	cfs
QOU	Flow from a node	cfs
SUMAL	Sum of cross-sectional area/length, for all pipes at node, not used presently	Feet
Y	Depth of water at a node at full integration step	Feet
YT	Depth of water at a node at half integration step	Feet
Z	Elevation of node invert	Feet
ZCROWN	Elevation of uppermost conduit crown at a node, defined as node crown elevation	Feet

TABLE 4-3
(continued)

Variable Name	Description	Units
	COMMON/LAB/	
	This common is used by the following subroutines BLOCK DATA CURVE INDATA OUTPUT PPLOT	
HORIZ	Horizontal label of curve	None
TITLE	Title printed out on curve	None
VERT	Vertical label	None
XLAB	Numerical scale labels for X	None
YLAB	Numerical scale labels for Y	None
	COMMON/LOSS/	
	This common is used by the following subroutines INDATA MAIN	
CLOSS	Entrance and exit losses	
	COMMON/ORF/	
	This common is used by the following subroutines BOUND INDATA	
AORIF	Cross-sectional area of orifice	Square Feet
CORIF	Orifice coefficient	None
LORIF	Internal orifice link number	None
NORIF	Number of orifices	None

TABLE 4-3
(continued)

Variable Name	Description	Units
	COMMON/OUT/	
	This common is used in the following subroutines INDATA MAIN OUTPUT	
CPRT	Conduit numbers for detailed printing	None
ICOL	Not used at this time	None
IDUM	Dummy array	None
INTER	Number of integration cycles between print cycles	
IPRT	Not used at this time	
JPLT	Node numbers for plotting	None
JPRT	Node numbers for detailed printing	None
KPLT	Conduit numbers for plotting	None
LPLT	Number of conduits for detailed printing	None
LTIME	Counter for printed output	None
NHPRT	Number of nodes for detailed printing	None
NPLT	Number of nodes to be plotted	None
NPRT	Not used at this time	None
NPTOT	Total number of plot data points	None
NQPRT	Number of conduits for detailed printing	None
NSTART	First cycle where saved printing array will begin	None
PRGEL	Print matrix, ground elevation	Feet
PRTH	Print matrix, water surface elevation	Feet

TABLE 4-3
(continued)

Variable Name	Description	Units
PRTQ	Print matrix, flow	cfs
PRTV	Print matrix, velocity	fps
PRTY	Print matrix, water depth at node	Feet
QPLT	Matrix of flow values	cfs
TPLT	Time used for plotting	Hours
YPLT	Matrix of water surface elevations	Feet
	COMMON/PIPE/	
	This common is used by the following subroutines BOUND DEPTH HEAD HYDRAD INDATA MAIN OUTPUT	
A	Full-step wetted cross section	Square Feet
AFULL	Full cross-sectional area of conduit	Square Feet
AT	Half-step wetted cross section	Square Feet
DEEP	Vertical dimension of conduit	Feet
H	Depth of flow at conduit ends	Feet
LEN	Conduit length	Feet
NCOND	External conduit number	None
NKLASS	Conduit shape classification 1. circular 2. rectangular 3. horseshoe 4. eggshape 5. baskethandle	None

TABLE 4-3
(continued)

Variable Name	Description	Units
NJUNC	External nodes at each end of conduit	None
Q	Flow in conduit at full integration step	cfs
QO	Saved flow values at beginning of each integration step	cfs
QT	Flow in conduit at half integration step	cfs
RFULL	Hydraulic radius of conduit when full	Feet
ROUGH	Manning coefficient	
V	Velocity in conduit at the full integration step	fps
VT	Velocity in conduit at the half integration step	fps
WIDE	Width of conduit	Feet
ZP	Height of conduit invert above node invert	Feet
	COMMON/PUMP/	
	This common is used in the following subroutines BOUND INDATA	
JPFUL	Internal integer switch for full wet well 0 = full 1 = not full	None
LPUMP	Internal pump linkage	None
NPUMP	Number of pumps	None
PRATE	Pumping rate	cfs
VRATE	Volume for changing pump rates	Cubic Feet
VWELL	Starting volume of pump wet well, also current wet-well volume after pumping starts	Cubic Feet

TABLE 4-3
(continued)

Variable Name	Description	Units
	COMMON/QUAL/	
	This common is used by the following subroutines INDATA INFLOW	
INQUAL	Dummy variable for read purposes	None
	COMMON/TIDE/	
	This common is used by the following subroutines INDATA TIDCF	
AA	Tidal curve fit coefficients during least square process	None
SXX	Matrix used by least square process	None
SXY	Vector used by least square process	None
TT	Clock time of tidal stage	Hours/Seconds
XX	Vector used in least square tide fit	None
YY	Stage of tidal input corresponding to TT	Feet
	COMMON/TRNQAL/	
	This common is used by the following subroutines INDATA MAIN	
N22	Tape unit number of hydraulic output for QUALITY TRANSPORT BLOCK	None

TABLE 4-3
(continued)

Variable Name	Description	Units
	COMMON/WEIR	
	This common is used in the following subroutines BOUND INDATA	
COEF	Coefficient of discharge for weir	None
COEFS	Coefficient of discharge for surcharged condition computed internally	None
KWEIR	Type of weir 1. transverse 2. transverse with tide gate 3. sideflow 4. sideflow with tide gate	None
LWEIR	Internal link number for weir	None
NWEIR	Number of weirs	None
WLEN	Weir length	Feet
YCREST	Height of weir crest above node invert	Feet
YTOP	Distance to tope of weir opening, above weir invert	Feet

EXAMPLE PROBLEM

An example problem is included in this report to show the user the form of the input and output from a typical run of the Analysis Module, and to provide an example of its capabilities. The Bellview-Redmond Road problem presented below meets both of these functions.

Bellview-Redmond Road is a two lane secondary highway which runs between the towns of Bellview and Redmond in the Seattle, Washington metropolitan area. An 850 foot section of this highway and its adjacent drainage system, shown in Figure 4-6, is used for this test. The schematic diagram of this area is found in Figure 4-7. Lines A,B, and C carry runoff from areas surrouding the highway to the highway drainage system and then to a free-flowing stream, represented by Line D. The highway drainage ditch, which also drains into D, is represented by Lines E,F, and G. Line G, as shown in Figure 4-8, also includes an underground drainage system which is tied into the roadside ditch with inlets. The inflow hydrographs shown result from the simulated runoff from a storm known to produce surcharge conditions in the system.

Two cases of this problem were run. The input data set for case 1, divided into card groups, is shown in Exhibit 4-1. Key sections of the output from this case can be found in Exhibit 4-2, which follows.

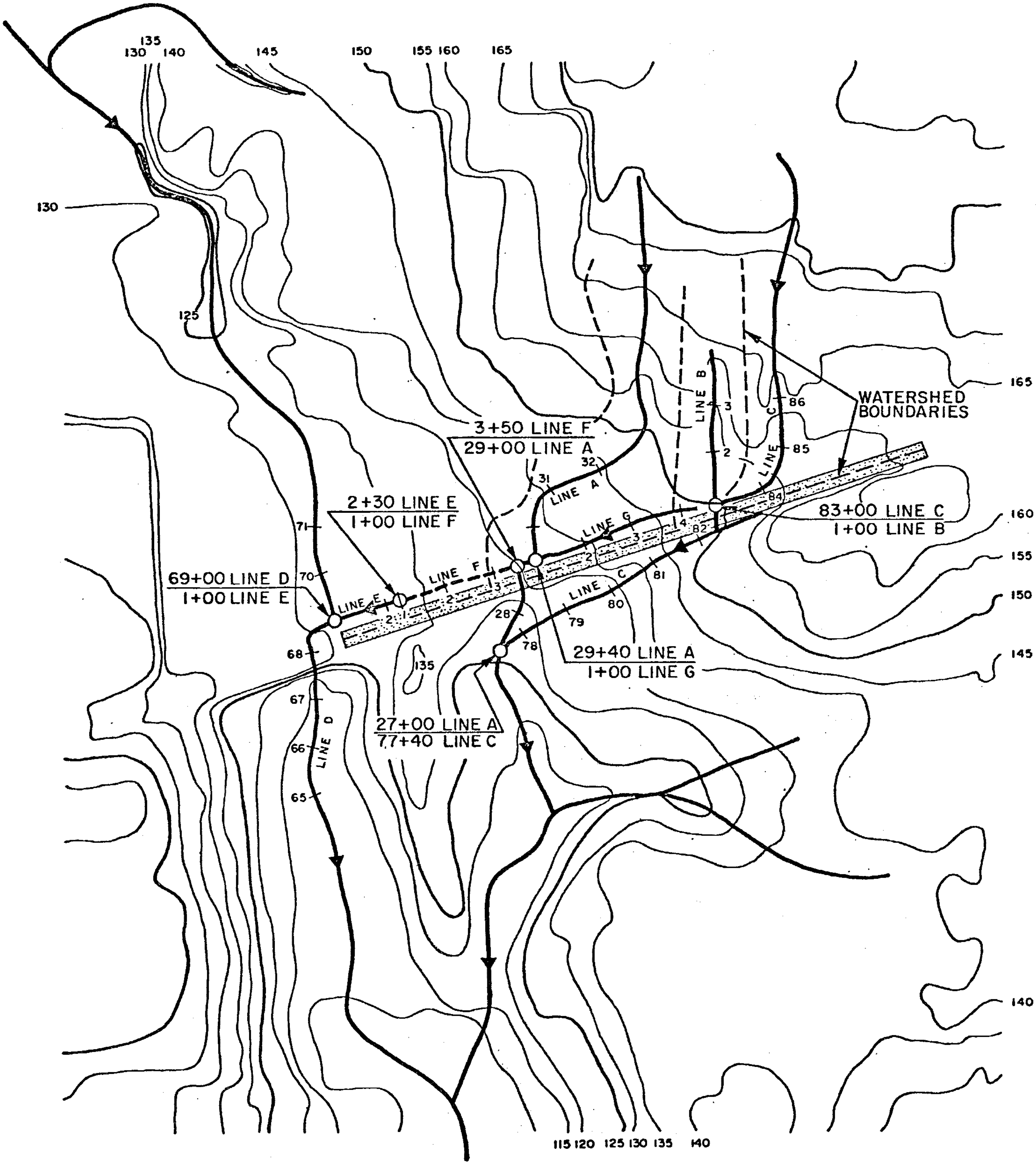


FIGURE 4-6. Base Map-Bellview-
Redmond Road Test Flow Routing Problem

Scale: 1"= 200'

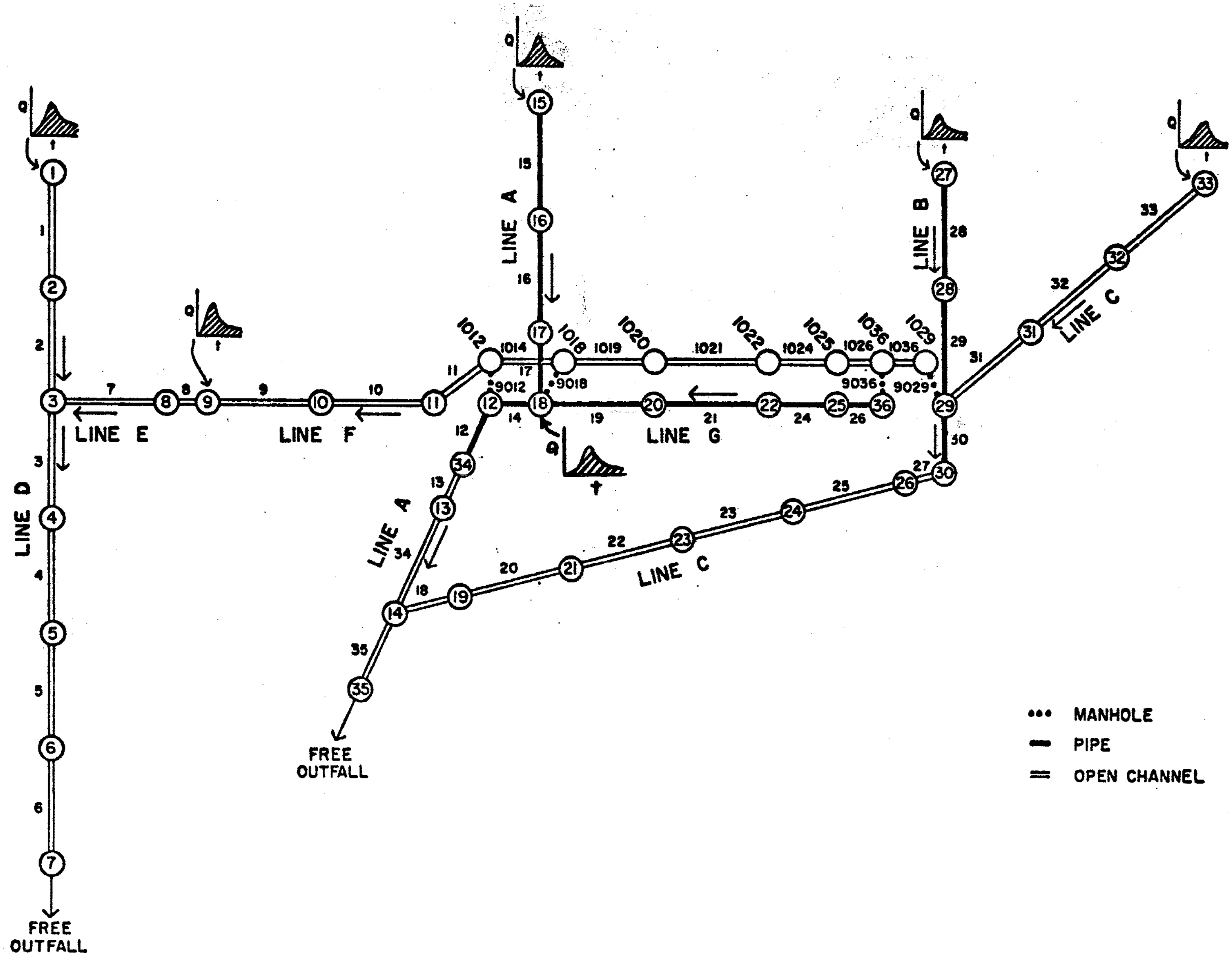


FIGURE 4-7. Schematic Diagram-
Bellview-Redmond Road Test Flow Routing
Problem

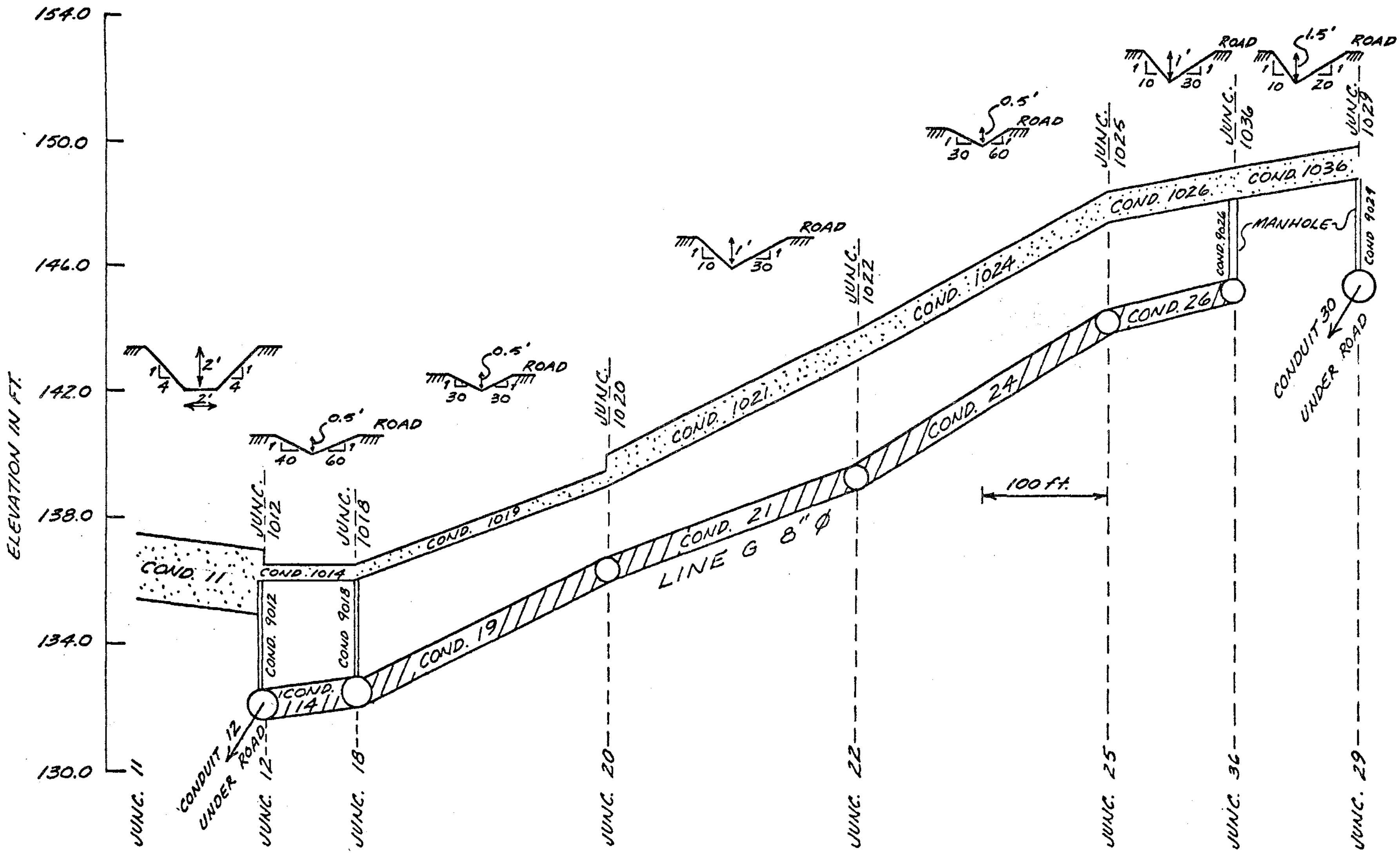


FIGURE 4-8. Profile and Surface Channel Cross-Sections for Line G

```
1 [                 ANALYSIS MODULE EXAMPLE PROBLEM
  [               BELLVIEW REDMOND ROAD DRAINAGE SYSTEM
2 -   720  10.   0.   18   16    4    6  121    6    6
3 [         31         28         30         29       1029       1036         36         22
  [       1025       1022       1020       1018         17         18       1018       1012
  [         12         11
4 [         29         31         30       1036       1026       1019         17         19
  [         14         12         11       1014       9012       9018       9036       9029
5 -         12         18         20         29
6 -         30       1036         19       1019         11         12
7 [    1    1    2    6       10.  16. 100.           .040  2.   2.
  [    2    2    3    6       10.  16. 100.           .040  2.   2.
  [    3    3    4    6       10.  16. 100.           .040  2.   2.
  [    4    4    5    6       10.  16. 100.           .040  2.   2.
  [    5    5    6    6       10.  16. 100.           .040  2.   2.
  [    6    6    7    6       10.  16. 100.           .040  2.   2.
  [    7    8    3    6        3.   2. 100.           .030  1.   1.
  [    8    9    8    6        3.   2.  30.           .030  1.   1.
  [    9   10    9    6        2.      100.           .025  4.   4.
  [   10   11   10    6        2.      100.           .025  4.   4.
  [   11 1012   11    6        2.       50.           .025  4.   4.
  [   35   14   35    6       1.6   2. 100.           .040  2.   2.
  [   34   13   14    6        1.   2. 100.           .030  2.   2.
  [   13   34   13    6        1.   2.  40.           .030  2.   2.
  [   12   12   34    1        1.   1.  60.           .015
  [   14   18   12    1        1.   1.  40.           .015
  [   17   17   18    1       1.5  1.5  60.           .015
  [   16   16   17    1       1.5  1.5 100.           .015
  [   15   15   16    1       1.5  1.5 100.           .015
  [   19   20   18    1        .7   .7 100.           .015
  [   21   22   20    1        .7   .7 100.           .015
  [   24   25   22    1        .7   .7 100.           .015
  [   26   36   25    1        .7   .7  50.           .015
  [   18   19   14    6       1.6   2.  60.           .040  2.   2.
  [   20   21   19    6       1.6   2. 100.           .040  2.   2.
  [   22   23   21    6       1.6   2. 100.           .040  2.   2.
  [   23   24   23    6       1.6   2. 100.           .040  2.   2.
  [   25   26   24    6       1.6   2. 100.           .040  2.   2.
  [   27   30   26    6       1.6   2.  40.           .040  2.   2.
  [   30   29   30    1       1.5  1.5  60.           .015
  [   29   28   29    1       1.5  1.5 100.           .015
  [   28   27   28    1       1.5  1.5 100.           .015
  [   31   31   29    6       1.6   2. 100.           .040  2.   2.
  [   32   32   31    6       1.6   2. 100.           .040  2.   2.
  [   33   33   32    6       1.6   2. 100.           .040  2.   2.
  [ 1014 1018 1012    6        .5       40.  1.5      .040 60.  40.
  [ 1019 1020 1018    6        .5      100.      1.5  .040 30.  30.
  [ 1021 1022 1020    6       1.0      100.           .040 30.  10.
  [ 1024 1025 1022    6        .5      100.           .040 60.  30.
  [ 1026 1036 1025    6       1.0      100.   .5      .040 30.  10.
  [ 1036 1029 1036    6       1.5       50.   .5   .5 .040 20.  10.
```

EXHIBIT 4-1. Bellview-Redmond Road Example Problem: Case 1 Input Data Set

```
     9012 1012   12   1        2.   2. 100.          .020
     9018 1018   18   1        2.   2. 100.          .015
     9029 1029   29   1        2.   2. 100.          .020
     9036 1036   36   1        2.   2. 100.          .020
    99999
        122.1512.15
        222.1012.10
        322.0512.05
        422.0012.00
        521.9511.95
        621.9011.90
        721.8511.85
        815.5012.50
        929.0026.00
       1034.0032.00
       1137.5035.50
     101237.0035.00
       3521.6120.00
       1426.6125.00
       1330.4029.40
       3432.5031.50
       1247.0031.70
       1837.0032.00
       1738.0033.00
       1641.0036.00
       1544.0040.00
8      2039.0036.00
       2243.0039.00
       2557.5044.00
       3658.8045.00
       1929.6028.00
       2133.6032.00
       2335.6034.00
       2443.6042.00
       2644.6043.00
       3050.0044.00
       2960.0045.00
       2852.5049.00
       2755.0051.00
       3152.6051.00
       3256.6055.00
       3361.6060.00
     102548.5047.50
     103649.3047.30
     102950.0048.00
     101836.5034.50
     102040.0039.00
     102244.0043.00
    99999
9   99999
10  99999
11  99999
```

EXHIBIT 4-1.
(Continued)

12 — 99999

13
7
35
99999

14 — 99999

15 — 1

18 — 99999.

20 — 1 9 15 18 27 33

21

.10	.00	.01	.10	.02	.02	.10
.20	5.00	.04	.50	.07	.06	.50
.30	10.00	.07	1.00	.13	.12	1.20
.40	20.00	.11	1.50	.20	.19	2.20
.50	30.00	.16	2.00	.30	.29	3.40
.60	40.00	.23	2.50	.40	.39	4.80
.70	50.00	.31	3.00	.60	.60	6.40
.80	80.00	.43	3.40	1.80	1.80	8.20
.90	110.00	.44	3.80	2.84	2.83	10.20
1.00	150.00	.44	4.20	3.85	3.86	12.70
1.10	200.00	.40	4.40	4.83	4.90	14.90
1.20	240.00	.39	4.60	4.81	4.89	15.40
1.30	260.00	.37	4.60	4.79	4.88	15.90
1.40	280.00	.34	4.50	4.77	4.87	15.20
1.50	300.00	.30	4.40	4.75	4.86	14.00
1.60	310.00	.26	4.30	.73	.84	13.00
1.70	315.00	.23	4.20	3.71	3.82	12.50
1.80	320.00	.20	4.10	3.69	3.80	12.00
1.90	330.00	.18	4.00	3.67	3.78	11.50
2.00	350.00	.16	3.90	2.65	2.76	11.00
2.10	380.00	.14	3.90	2.64	2.74	10.50

EXHIBIT 4-1.
(Continued)

EXHIBIT 4-2

Bellview-Redmond Road
Example Problem:
Case 1 Results

FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

INTEGRATION CYCLES 720

LENGTH OF INTEGRATION STEP IS 10. SECONDS

PRINTING STARTS IN CYCLE 121 AND PRINTS AT INTERVALS OF 6 CYCLES

INITIAL TIME 0.00 HOURS

PRINTED OUTPUT AT THE FOLLOWING 18 JUNCTIONS

31	28	30	29	1029	1036	36	22	1025
1022	1020	1018	17	18	1018	1012	12	11

AND FOR THE FOLLOWING 16 CONDUITS

29	31	30	1036	1026	1019	17	19	14
12	11	1014	9012	9018	9036	9029		

WATER SURFACE ELEVATIONS WILL BE PLOTTED FOR THE FOLLOWING 4 JUNCTIONS

12	18	20	29

FLOW RATE WILL BE PLOTTED FOR THE FOLLOWING 6 CONDUITS

30	1036	19	1019	11	12

FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

	CONDUIT NUMBER	LENGTH (FT)	CLASS	AREA (SQ FT)	MANNING COEF.	MAX WIDTH (FT)	DEPTH (FT)	JUNCTIONS AT ENDS		INVERT HEIGHT ABOVE JUNCTIONS		TRAPEZOID SIDE SLOPE
1	1	100.	6	360.00	0.040	16.00	10.00	1	2			2.00 2.00
2	2	100.	6	360.00	0.040	16.00	10.00	2	3			2.00 2.00
3	3	100.	6	360.00	0.040	16.00	10.00	3	4			2.00 2.00
4	4	100.	6	360.00	0.040	16.00	10.00	4	5			2.00 2.00
5	5	100.	6	360.00	0.040	16.00	10.00	5	6			2.00 2.00
6	6	100.	6	360.00	0.040	16.00	10.00	6	7			2.00 2.00
7	7	100.	6	15.00	0.030	2.00	3.00	8	3			1.00 1.00
8	8	30.	6	15.00	0.030	2.00	3.00	9	8			1.00 1.00
9	9	100.	6	16.00	0.025	0.01	2.00	10	9			4.00 4.00
10	10	100.	6	16.00	0.025	0.01	2.00	11	10			4.00 4.00
11	11	50.	6	16.00	0.025	0.01	2.00	1012	11			4.00 4.00
12	35	100.	6	8.32	0.040	2.00	1.60	14	35			2.00 2.00
13	34	100.	6	4.00	0.030	2.00	1.00	13	14			2.00 2.00
14	13	40.	6	4.00	0.030	2.00	1.00	34	13			2.00 2.00
15	12	60.	1	0.79	0.015	1.00	1.00	12	34			
16	14	40.	1	0.79	0.015	1.00	1.00	18	12			
17	17	60.	1	1.77	0.015	1.50	1.50	17	18			
18	16	100.	1	1.77	0.015	1.50	1.50	16	17			
19	15	100.	1	1.77	0.015	1.50	1.50	15	16			
20	19	100.	1	0.38	0.015	0.70	0.70	20	18			
21	21	100.	1	0.38	0.015	0.70	0.70	22	20			
22	24	100.	1	0.38	0.015	0.70	0.70	25	22			
23	26	50.	1	0.38	0.015	0.70	0.70	36	25			
24	18	60.	6	8.32	0.040	2.00	1.60	19	14			2.00 2.00
25	20	100.	6	8.32	0.040	2.00	1.60	21	19			2.00 2.00
26	22	100.	6	8.32	0.040	2.00	1.60	23	21			2.00 2.00
27	23	100.	6	8.32	0.040	2.00	1.60	24	23			2.00 2.00
28	25	100.	6	8.32	0.040	2.00	1.60	26	24			2.00 2.00
29	27	40.	6	8.32	0.040	2.00	1.60	30	26			2.00 2.00
30	30	60.	1	1.77	0.015	1.50	1.50	29	30			
31	29	100.	1	1.77	0.015	1.50	1.50	28	29			
32	28	100.	1	1.77	0.015	1.50	1.50	27	28			
33	31	100.	6	8.32	0.040	2.00	1.60	31	29			2.00 2.00
34	32	100.	6	8.32	0.040	2.00	1.60	32	31			2.00 2.00
35	33	100.	6	8.32	0.040	2.00	1.60	33	32			2.00 2.00
36	1014	40.	6	12.50	0.040	0.01	0.50	1018	1012	1.50	0.00	60.0040.00
37	1019	100.	6	7.50	0.040	0.01	0.50	1020	1018	0.00	1.50	30.0030.00
38	1021	100.	6	20.00	0.040	0.01	1.00	1022	1020			30.0010.00
39	1024	100.	6	11.25	0.040	0.01	0.50	1025	1022			60.0030.00
40	1026	100.	6	20.00	0.040	0.01	1.00	1036	1025	0.50	0.00	30.0010.00
41	1036	50.	6	33.75	0.040	0.01	1.50	1029	1036	0.50	0.50	20.0010.00
42	9012	100.	1	3.14	0.020	2.00	2.00	1012	12			
43	9018	100.	1	3.14	0.015	2.00	2.00	1018	18			
44	9029	100.	1	3.14	0.020	2.00	2.00	1029	29			
45	9036	100.	1	3.14	0.020	2.00	2.00	1036	36			

**** WARNING **** (C*DELT/LEN) IN CONDUIT 1 IS 1.8 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 2 IS 1.8 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 3 IS 1.8 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 4 IS 1.8 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 5 IS 1.8 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 6 IS 1.8 AT FULL DEPTH.

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**** WARNING **** (C*DELT/LEN) IN CONDUIT    8 IS  3.3 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   11 IS  1.6 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   13 IS  1.4 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   14 IS  1.4 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   17 IS  1.2 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   18 IS  1.2 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   27 IS  1.8 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   30 IS  1.2 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 1014 IS  1.0 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 1036 IS  1.4 AT FULL DEPTH.
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ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

	JUNCTION NUMBER	GROUND ELEV.	CROWN ELEV.	INVERT ELEV.	QINST (CFS)	CONNECTING CONDUITS			
1	1	22.15	22.15	12.15	0.00	1			
2	2	22.10	22.10	12.10	0.00	1	2		
3	3	22.05	22.05	12.05	0.00	2	3	7	
4	4	22.00	22.00	12.00	0.00	3	4		
5	5	21.95	21.95	11.95	0.00	4	5		
6	6	21.90	21.90	11.90	0.00	5	6		
7	7	21.85	21.85	11.85	0.00	6			
8	8	15.50	15.50	12.50	0.00	7	8		
9	9	29.00	29.00	26.00	0.00	8	9		
10	10	34.00	34.00	32.00	0.00	9	10		
11	11	37.50	37.50	35.50	0.00	10	11		
12	1012	37.00	37.00	35.00	0.00	11	1014	9012	
13	35	21.61	21.60	20.00	0.00	35			
14	14	26.61	26.60	25.00	0.00	35	34	18	
15	13	30.40	30.40	29.40	0.00	34	13		
16	34	32.50	32.50	31.50	0.00	13	12		
17	12	47.00	33.70	31.70	0.00	12	14	9012	
18	18	37.00	34.00	32.00	0.00	14	17	19	9018
19	17	38.00	34.50	33.00	0.00	17	16		
20	16	41.00	37.50	36.00	0.00	16	15		
21	15	44.00	41.50	40.00	0.00	15			
22	20	39.00	36.70	36.00	0.00	19	21		
23	22	43.00	39.70	39.00	0.00	21	24		
24	25	57.50	44.70	44.00	0.00	24	26		
25	36	58.80	47.00	45.00	0.00	26	9036		
26	19	29.60	29.60	28.00	0.00	18	20		
27	21	33.60	33.60	32.00	0.00	20	22		
28	23	35.60	35.60	34.00	0.00	22	23		
29	24	43.60	43.60	42.00	0.00	23	25		
30	26	44.60	44.60	43.00	0.00	25	27		
31	30	50.00	45.60	44.00	0.00	27	30		
32	29	60.00	47.00	45.00	0.00	30	29	31	9029
33	28	52.50	50.50	49.00	0.00	29	28		
34	27	55.00	52.50	51.00	0.00	28			
35	31	52.60	52.60	51.00	0.00	31	32		
36	32	56.60	56.60	55.00	0.00	32	33		
37	33	61.60	61.60	60.00	0.00	33			
38	1025	48.50	48.50	47.50	0.00	1024	1026		
39	1036	49.30	49.30	47.30	0.00	1026	1036	9036	
40	1029	50.00	50.00	48.00	0.00	1036	9029		
41	1018	36.50	36.50	34.50	0.00	1014	1019	9018	
42	1020	40.00	40.00	39.00	0.00	1019	1021		
43	1022	44.00	44.00	43.00	0.00	1021	1024		

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

FREE OUTFALL DATA

FREE OUTFLOW AT JUNCTIONS 7 35

INTERNAL CONNECTIVITY INFORMATION

CONDUIT	JUNCTION	JUNCTION
90046	7	0
90047	35	0

SUMMARY OF INITIAL HEADS, FLOWS AND VELOCITIES

INITIAL HEADS, FLOWS AND VELOCITIES ARE ZERO

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

****** SYSTEM INFLOWS (CARDS) AT 0.10 HOURS FOR 6 JUNCTIONS

1/ 0.00	9/ 0.01	15/ 0.10	18/ 0.02	27/ 0.02	33/ 0.10

****** SYSTEM INFLOWS (CARDS) AT 0.20 HOURS (JUNCTION / INFLOW,CFS)

1/ 5.00	9/ 0.04	15/ 0.50	18/ 0.07	27/ 0.06	33/ 0.50

CYCLE 6 TIME 0 HRS - 1.00 MIN

JUNCTIONS / DEPTHS

1/ 0.37	2/ 0.18	3/ 0.01	4/ 0.00	5/ 0.00	6/ 0.00	7/ 0.00	8/ 0.13
9/ 0.00	10/ 0.00	11/ 0.00	1012/ 0.00	35/ 0.00	14/ 0.00	13/ 0.00	
34/ 0.00	12/ 0.00	18/ 0.05	17/ 0.15	16/ 0.13	15/ 0.00	20/ 0.00	
22/ 0.00	25/ 0.00	36/ 0.00	19/ 0.00	21/ 0.00	23/ 0.00	24/ 0.00	
26/ 0.00	30/ 0.00	29/ 0.01	28/ 0.00	27/ 0.00	31/ 0.01	32/ 0.13	
33/ 0.00	1025/ 0.00	1036/ 0.00	1029/ 0.00	1018/ 0.00	1020/ 0.00	1022/ 0.00	

CONDUITS / FLOWS

1/ 3.58	2/ 0.55	3/ 0.00	4/ 0.00	5/ 0.00	6/ 0.00	7/ 0.08	8/ 0.00
9/ 0.00	10/ 0.00	11/ 0.00	35/ 0.00	34/ 0.00	13/ 0.00	12/ 0.00	
14/ 0.00	17/ 0.15	16/ 0.30	15/ 0.00	19/ 0.00	21/ 0.00	24/ 0.00	
26/ 0.00	18/ 0.00	20/ 0.00	22/ 0.00	23/ 0.00	25/ 0.00	27/ 0.00	
30/ 0.00	29/ 0.00	28/ 0.00	31/ 0.01	32/ 0.11	33/ 0.00	1014/ 0.00	
1019/ 0.00	1021/ 0.00	1024/ 0.00	1026/ 0.00	1036/ 0.00	9012/ 0.00	9018/ 0.00	
9029/ 0.00	9036/ 0.00	90046/ 0.00	90047/ 0.00				

A summary of junction depths and conduit flows as shown above is printed at every INTER cycles.

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- - - - - - - - - - - - - - - - - - - - - - - - CONTINUITY BALANCE AT END OF RUN - - - - - - - - - - - - - - - - - - - - -

TOTAL SYSTEM INFLOW VOLUME =    1284473. CU FT

JUNCTION OUTFLOWS AND
STREET FLOODING

   JUNCTION  OUTFLOW, FT3

        7       989845.
        8       137486.
       35       102960.
          --------------
          TOTAL              1230291. CU FT

VOLUME LEFT IN SYSTEM =         57415. CU FT

ERROR IN CONTINUITY, PERCENT = -0.25
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ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

********************* TIME HISTORY OF H. G. L. *********************
(VALUES IN FEET)

TIME	JUNCTION 31 GRND 52.60		JUNCTION 28 GRND 52.50		JUNCTION 30 GRND 50.00		JUNCTION 29 GRND 60.00		JUNCTION 1029 GRND 50.00		JUNCTION 1036 GRND 49.30	
HR . MIN	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH
0.20	51.21	0.21	49.09	0.09	44.26	0.26	45.46	0.46	48.00	0.00	47.30	0.00
0.21	51.22	0.22	49.10	0.10	44.28	0.28	45.49	0.49	48.00	0.00	47.30	0.00
0.22	51.23	0.23	49.10	0.10	44.29	0.29	45.52	0.52	48.00	0.00	47.30	0.00
0.23	51.25	0.25	49.10	0.10	44.31	0.31	45.55	0.55	48.00	0.00	47.30	0.00
0.24	51.26	0.26	49.11	0.11	44.33	0.33	45.58	0.58	48.00	0.00	47.30	0.00
0.25	51.27	0.27	49.11	0.11	44.35	0.35	45.61	0.61	48.00	0.00	47.30	0.00
0.26	51.28	0.28	49.11	0.11	44.36	0.36	45.64	0.64	48.00	0.00	47.30	0.00
0.27	51.30	0.30	49.12	0.12	44.38	0.38	45.67	0.67	48.00	0.00	47.30	0.00
0.28	51.31	0.31	49.12	0.12	44.40	0.40	45.70	0.70	48.00	0.00	47.30	0.00
0.29	51.32	0.32	49.13	0.13	44.41	0.41	45.73	0.73	48.00	0.00	47.30	0.00
0.30	51.33	0.33	49.13	0.13	44.43	0.43	45.76	0.76	48.00	0.00	47.30	0.00
0.31	51.35	0.35	49.13	0.13	44.44	0.44	45.79	0.79	48.00	0.00	47.30	0.00
0.32	51.36	0.36	49.14	0.14	44.46	0.46	45.82	0.82	48.00	0.00	47.30	0.00
0.33	51.37	0.37	49.14	0.14	44.48	0.48	45.85	0.85	48.00	0.00	47.30	0.00
0.34	51.38	0.38	49.14	0.14	44.49	0.49	45.88	0.88	48.00	0.00	47.30	0.00
0.35	51.40	0.40	49.15	0.15	44.51	0.51	45.92	0.92	48.00	0.00	47.30	0.00
0.36	51.41	0.41	49.15	0.15	44.52	0.52	45.95	0.95	48.00	0.00	47.30	0.00
0.37	51.42	0.42	49.16	0.16	44.54	0.54	45.98	0.98	48.00	0.00	47.30	0.00
0.38	51.43	0.43	49.16	0.16	44.55	0.55	46.02	1.02	48.00	0.00	47.30	0.00
0.39	51.44	0.44	49.17	0.17	44.57	0.57	46.05	1.05	48.00	0.00	47.30	0.00
0.40	51.45	0.45	49.17	0.17	44.58	0.58	46.09	1.09	48.00	0.00	47.30	0.00
0.41	51.47	0.47	49.18	0.18	44.60	0.60	46.13	1.13	48.00	0.00	47.30	0.00
0.42	51.48	0.48	49.19	0.19	44.61	0.61	46.17	1.17	48.00	0.00	47.30	0.00
0.43	51.49	0.49	49.21	0.21	44.63	0.63	46.21	1.21	48.00	0.00	47.30	0.00
0.44	51.50	0.50	49.23	0.23	44.65	0.65	46.27	1.27	48.00	0.00	47.30	0.00
0.45	51.51	0.51	49.26	0.26	44.67	0.67	46.33	1.33	48.00	0.00	47.30	0.00
0.46	51.52	0.52	49.28	0.28	44.69	0.69	46.40	1.40	48.00	0.00	47.30	0.00
0.47	51.53	0.53	49.30	0.30	44.71	0.71	46.47	1.47	48.00	0.00	47.30	0.00
0.48	51.55	0.55	49.32	0.32	44.73	0.73	46.54	1.54	48.00	0.00	47.30	0.00
0.49	51.56	0.56	49.33	0.33	44.76	0.76	46.61	1.61	48.00	0.00	47.30	0.00
0.50	51.57	0.57	49.35	0.35	44.78	0.78	46.68	1.68	48.00	0.00	47.30	0.00
0.51	51.58	0.58	49.36	0.36	44.79	0.79	46.74	1.74	48.00	0.00	47.30	0.00
0.52	51.59	0.59	49.37	0.37	44.81	0.81	46.81	1.81	48.00	0.00	47.30	0.00
0.53	51.60	0.60	49.39	0.39	44.83	0.83	46.89	1.89	48.00	0.00	47.30	0.00
0.54	51.61	0.61	49.40	0.40	44.84	0.84	46.96	1.96	48.00	0.00	47.30	0.00
0.55	51.62	0.62	49.41	0.41	44.86	0.86	47.07	2.00	48.00	0.00	47.30	0.00
0.56	51.64	0.64	49.42	0.42	44.88	0.88	47.33	2.00	48.00	0.00	47.30	0.00
0.57	51.65	0.65	49.44	0.44	44.91	0.91	47.56	2.00	48.00	0.00	47.30	0.00
0.58	51.66	0.66	49.45	0.45	44.93	0.93	47.74	2.00	48.00	0.00	47.30	0.00
0.59	51.68	0.68	49.46	0.46	44.95	0.95	47.91	2.00	48.00	0.00	47.30	0.00
1. 0	51.69	0.69	49.47	0.47	44.97	0.97	48.05	2.00	48.05	0.05	47.30	0.00
1. 1	51.70	0.70	49.48	0.48	44.98	0.98	48.20	2.00	48.20	0.20	47.30	0.00
1. 2	51.71	0.71	49.49	0.49	45.00	1.00	48.35	2.00	48.35	0.35	47.30	0.00
1. 3	51.72	0.72	49.50	0.50	45.01	1.01	48.50	2.00	48.50	0.50	47.30	0.00
1. 4	51.73	0.73	49.51	0.51	45.02	1.02	48.64	2.00	48.63	0.63	47.34	0.04

1. 5	51.74	0.74	49.52	0.52	45.03	1.03	48.73	2.00	48.71	0.71	47.53	0.23
1. 6	51.75	0.75	49.53	0.53	45.04	1.04	48.79	2.00	48.77	0.77	47.55	0.25
1. 7	51.75	0.75	49.53	0.53	45.04	1.04	48.82	2.00	48.81	0.81	47.60	0.30
1. 8	51.75	0.75	49.53	0.53	45.04	1.04	48.83	2.00	48.81	0.81	47.62	0.32
1. 9	51.76	0.76	49.53	0.53	45.05	1.05	48.84	2.00	48.82	0.82	47.63	0.33
1.10	51.76	0.76	49.53	0.53	45.05	1.05	48.85	2.00	48.83	0.83	47.64	0.34
1.11	51.76	0.76	49.53	0.53	45.05	1.05	48.85	2.00	48.83	0.83	47.64	0.34
1.12	51.76	0.76	49.53	0.53	45.05	1.05	48.86	2.00	48.83	0.83	47.65	0.35
1.13	51.77	0.77	49.53	0.53	45.05	1.05	48.86	2.00	48.84	0.84	47.66	0.36
1.14	51.77	0.77	49.53	0.53	45.05	1.05	48.87	2.00	48.84	0.84	47.66	0.36
1.15	51.77	0.77	49.53	0.53	45.05	1.05	48.88	2.00	48.85	0.85	47.67	0.37
1.16	51.77	0.77	49.53	0.53	45.05	1.05	48.88	2.00	48.85	0.85	47.68	0.38
1.17	51.77	0.77	49.53	0.53	45.05	1.05	48.89	2.00	48.86	0.86	47.68	0.38
1.18	51.78	0.78	49.53	0.53	45.05	1.05	48.90	2.00	48.86	0.86	47.69	0.39
1.19	51.77	0.77	49.53	0.53	45.05	1.05	48.90	2.00	48.86	0.86	47.69	0.39
1.20	51.77	0.77	49.53	0.53	45.05	1.05	48.89	2.00	48.86	0.86	47.69	0.39
1.21	51.77	0.77	49.53	0.53	45.05	1.05	48.88	2.00	48.85	0.85	47.68	0.38
1.22	51.77	0.77	49.53	0.53	45.05	1.05	48.87	2.00	48.85	0.85	47.67	0.37
1.23	51.76	0.76	49.53	0.53	45.05	1.05	48.86	2.00	48.84	0.84	47.66	0.36
1.24	51.76	0.76	49.53	0.53	45.05	1.05	48.85	2.00	48.83	0.83	47.65	0.35
1.25	51.76	0.76	49.53	0.53	45.05	1.05	48.84	2.00	48.83	0.83	47.64	0.34
1.26	51.75	0.75	49.53	0.53	45.04	1.04	48.83	2.00	48.81	0.81	47.62	0.32
1.27	51.75	0.75	49.53	0.53	45.04	1.04	48.81	2.00	48.80	0.80	47.60	0.30
1.28	51.74	0.74	49.53	0.53	45.04	1.04	48.79	2.00	48.79	0.79	47.59	0.29
1.29	51.74	0.74	49.53	0.53	45.04	1.04	48.77	2.00	48.77	0.77	47.57	0.27
1.30	51.73	0.73	49.53	0.53	45.04	1.04	48.76	2.00	48.75	0.75	47.54	0.24
1.31	51.73	0.73	49.49	0.49	45.03	1.03	48.70	2.00	48.71	0.71	47.49	0.19
1.32	51.72	0.72	49.45	0.45	45.02	1.02	48.60	2.00	48.60	0.60	47.40	0.10
1.33	51.72	0.72	49.40	0.40	45.01	1.01	48.42	2.00	48.42	0.42	47.34	0.04
1.34	51.71	0.71	49.35	0.35	44.98	0.98	48.20	2.00	48.20	0.20	47.32	0.02
1.35	51.71	0.71	49.29	0.29	44.96	0.96	47.94	2.00	48.06	0.06	47.31	0.01
1.36	51.70	0.70	49.23	0.23	44.93	0.93	47.69	2.00	48.03	0.03	47.31	0.01
1.37	51.70	0.70	49.27	0.27	44.91	0.91	47.58	2.00	48.02	0.02	47.30	0.00
1.38	51.70	0.70	49.32	0.32	44.92	0.92	47.64	2.00	48.01	0.01	47.30	0.00
1.39	51.69	0.69	49.36	0.36	44.93	0.93	47.75	2.00	48.01	0.01	47.30	0.00
1.40	51.69	0.69	49.40	0.40	44.95	0.95	47.87	2.00	48.01	0.01	47.30	0.00
1.41	51.69	0.69	49.44	0.44	44.96	0.96	47.99	2.00	48.01	0.01	47.30	0.00
1.42	51.69	0.69	49.47	0.47	44.97	0.97	48.08	2.00	48.08	0.08	47.30	0.00
1.43	51.69	0.69	49.47	0.47	44.98	0.98	48.14	2.00	48.14	0.14	47.30	0.00
1.44	51.68	0.68	49.47	0.47	44.98	0.98	48.14	2.00	48.15	0.15	47.30	0.00
1.45	51.68	0.68	49.47	0.47	44.97	0.97	48.13	2.00	48.13	0.13	47.30	0.00
1.46	51.68	0.68	49.47	0.47	44.97	0.97	48.11	2.00	48.11	0.11	47.30	0.00
1.47	51.68	0.68	49.47	0.47	44.97	0.97	48.09	2.00	48.09	0.09	47.30	0.00
1.48	51.67	0.67	49.47	0.47	44.97	0.97	48.06	2.00	48.06	0.06	47.30	0.00
1.49	51.67	0.67	49.46	0.46	44.96	0.96	48.04	2.00	48.04	0.04	47.30	0.00
1.50	51.67	0.67	49.46	0.46	44.96	0.96	48.01	2.00	48.02	0.02	47.30	0.00
1.51	51.67	0.67	49.46	0.46	44.96	0.96	47.98	2.00	48.01	0.01	47.30	0.00
1.52	51.66	0.66	49.46	0.46	44.96	0.96	47.96	2.00	48.01	0.01	47.30	0.00
1.53	51.66	0.66	49.46	0.46	44.95	0.95	47.93	2.00	48.01	0.01	47.30	0.00
1.54	51.66	0.66	49.46	0.46	44.95	0.95	47.91	2.00	48.01	0.01	47.30	0.00
1.55	51.66	0.66	49.45	0.45	44.95	0.95	47.86	2.00	48.00	0.00	47.30	0.00
1.56	51.65	0.65	49.44	0.44	44.94	0.94	47.80	2.00	48.00	0.00	47.30	0.00
1.57	51.65	0.65	49.43	0.43	44.93	0.93	47.73	2.00	48.00	0.00	47.30	0.00
1.58	51.65	0.65	49.42	0.42	44.92	0.92	47.66	2.00	48.00	0.00	47.30	0.00
1.59	51.65	0.65	49.41	0.41	44.92	0.92	47.59	2.00	48.00	0.00	47.30	0.00

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

*********************** TIME HISTORY OF H.G.L. ***********************
(VALUES IN FEET)

TIME	JUNCTION 36 GRND 58.80		JUNCTION 22 GRND 43.00		JUNCTION 1025 GRND 48.50		JUNCTION 1022 GRND 44.00		JUNCTION 1020 GRND 40.00		JUNCTION 1018 GRND 36.50	
HR . MIN	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH
0.20	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.21	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.22	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.23	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.24	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.25	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.26	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.27	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.28	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.29	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.30	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.31	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.32	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.33	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.34	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.35	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.36	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.37	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.38	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.39	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.40	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.41	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.42	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.43	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.44	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.45	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.52	0.02
0.46	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.75	0.25
0.47	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.99	0.49
0.48	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	35.25	0.75
0.49	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	35.54	1.04
0.50	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	35.84	1.34
0.51	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.06	1.56
0.52	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.13	1.63
0.53	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.17	1.67
0.54	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.18	1.68
0.55	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.20	1.70
0.56	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.21	1.71
0.57	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.22	1.72
0.58	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.23	1.73
0.59	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.24	1.74
1. 0	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.25	1.75
1. 1	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1. 2	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1. 3	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.27	1.77
1. 4	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.27	1.77

1. 5	45.10	0.10	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.28	1.78
1. 6	45.33	0.33	39.10	0.10	47.50	0.00	43.00	0.00	39.00	0.00	36.28	1.78
1. 7	45.46	0.46	39.28	0.28	47.50	0.00	43.00	0.00	39.00	0.00	36.29	1.79
1. 8	45.58	0.58	39.36	0.36	47.50	0.00	43.00	0.00	39.00	0.00	36.30	1.80
1. 9	45.63	0.63	39.39	0.39	47.50	0.00	43.00	0.00	39.00	0.00	36.30	1.80
1.10	45.66	0.66	39.40	0.40	47.50	0.00	43.00	0.00	39.00	0.00	36.31	1.81
1.11	45.69	0.69	39.41	0.41	47.50	0.00	43.00	0.00	39.00	0.00	36.32	1.82
1.12	45.73	0.73	39.42	0.42	47.50	0.00	43.00	0.00	39.00	0.00	36.33	1.83
1.13	45.76	0.76	39.45	0.45	47.50	0.00	43.00	0.00	39.00	0.00	36.34	1.84
1.14	45.79	0.79	39.51	0.51	47.50	0.00	43.00	0.00	39.00	0.00	36.34	1.84
1.15	45.83	0.83	39.62	0.62	47.50	0.00	43.00	0.00	39.00	0.00	36.35	1.85
1.16	45.86	0.86	40.06	0.70	47.50	0.00	43.00	0.00	39.00	0.00	36.35	1.85
1.17	45.90	0.90	40.50	0.70	47.50	0.00	43.00	0.00	39.00	0.00	36.36	1.86
1.18	45.95	0.95	40.73	0.70	47.50	0.00	43.00	0.00	39.00	0.00	36.36	1.86
1.19	46.03	1.03	40.78	0.70	47.50	0.00	43.00	0.00	39.00	0.00	36.37	1.87
1.20	46.09	1.09	40.99	0.70	47.50	0.00	43.00	0.00	39.00	0.00	36.37	1.87
1.21	46.09	1.09	41.10	0.70	47.50	0.00	43.00	0.00	39.00	0.00	36.37	1.87
1.22	46.04	1.04	41.02	0.70	47.50	0.00	43.00	0.00	39.00	0.00	36.37	1.87
1.23	45.97	0.97	40.82	0.70	47.50	0.00	43.00	0.00	39.00	0.00	36.37	1.87
1.24	45.86	0.86	40.66	0.70	47.50	0.00	43.00	0.00	39.00	0.00	36.37	1.87
1.25	45.77	0.77	40.09	0.70	47.50	0.00	43.00	0.00	39.00	0.00	36.37	1.87
1.26	45.70	0.70	39.67	0.67	47.50	0.00	43.00	0.00	39.00	0.00	36.37	1.87
1.27	45.63	0.63	39.48	0.48	47.50	0.00	43.00	0.00	39.00	0.00	36.36	1.86
1.28	45.56	0.56	39.37	0.37	47.50	0.00	43.00	0.00	39.00	0.00	36.36	1.86
1.29	45.51	0.51	39.34	0.34	47.50	0.00	43.00	0.00	39.00	0.00	36.35	1.85
1.30	45.45	0.45	39.31	0.31	47.50	0.00	43.00	0.00	39.00	0.00	36.34	1.84
1.31	45.39	0.39	39.28	0.28	47.50	0.00	43.00	0.00	39.00	0.00	36.32	1.82
1.32	45.25	0.25	39.22	0.22	47.50	0.00	43.00	0.00	39.00	0.00	36.29	1.79
1.33	45.13	0.13	39.14	0.14	47.50	0.00	43.00	0.00	39.00	0.00	36.27	1.77
1.34	45.07	0.07	39.09	0.09	47.50	0.00	43.00	0.00	39.00	0.00	36.25	1.75
1.35	45.05	0.05	39.06	0.06	47.50	0.00	43.00	0.00	39.00	0.00	36.23	1.73
1.36	45.04	0.04	39.05	0.05	47.50	0.00	43.00	0.00	39.00	0.00	36.21	1.71
1.37	45.03	0.03	39.04	0.04	47.50	0.00	43.00	0.00	39.00	0.00	36.20	1.70
1.38	45.03	0.03	39.03	0.03	47.50	0.00	43.00	0.00	39.00	0.00	36.21	1.71
1.39	45.02	0.02	39.03	0.03	47.50	0.00	43.00	0.00	39.00	0.00	36.22	1.72
1.40	45.02	0.02	39.02	0.02	47.50	0.00	43.00	0.00	39.00	0.00	36.23	1.73
1.41	45.02	0.02	39.02	0.02	47.50	0.00	43.00	0.00	39.00	0.00	36.24	1.74
1.42	45.02	0.02	39.02	0.02	47.50	0.00	43.00	0.00	39.00	0.00	36.25	1.75
1.43	45.01	0.01	39.02	0.02	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1.44	45.01	0.01	39.02	0.02	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1.45	45.01	0.01	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1.46	45.01	0.01	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1.47	45.01	0.01	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1.48	45.01	0.01	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1.49	45.01	0.01	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1.50	45.01	0.01	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1.51	45.01	0.01	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1.52	45.01	0.01	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1.53	45.01	0.01	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1.54	45.00	0.00	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.26	1.76
1.55	45.00	0.00	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.25	1.75
1.56	45.00	0.00	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.25	1.75
1.57	45.00	0.00	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.25	1.75
1.58	45.00	0.00	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	36.24	1.74
1.59	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	36.24	1.74

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

********************* TIME HISTORY OF H. G. L. *********************
(VALUES IN FEET)

TIME	JUNCTION 17		JUNCTION 18		JUNCTION 1018		JUNCTION 1012		JUNCTION 12		JUNCTION 11	
	GRND 38.00		GRND 37.00		GRND 36.50		GRND 37.00		GRND 47.00		GRND 37.50	
HR . MIN	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH
0.20	33.32	0.32	32.53	0.53	34.50	0.00	35.00	0.00	32.50	0.80	35.50	0.00
0.21	33.33	0.33	32.58	0.58	34.50	0.00	35.00	0.00	32.54	0.84	35.50	0.00
0.22	33.34	0.34	32.62	0.62	34.50	0.00	35.00	0.00	32.57	0.87	35.50	0.00
0.23	33.35	0.35	32.67	0.67	34.50	0.00	35.00	0.00	32.61	0.91	35.50	0.00
0.24	33.36	0.36	32.72	0.72	34.50	0.00	35.00	0.00	32.65	0.95	35.50	0.00
0.25	33.37	0.37	32.77	0.77	34.50	0.00	35.00	0.00	32.69	0.99	35.50	0.00
0.26	33.38	0.38	32.84	0.84	34.50	0.00	35.00	0.00	32.74	1.04	35.50	0.00
0.27	33.39	0.39	32.90	0.90	34.50	0.00	35.00	0.00	32.78	1.08	35.50	0.00
0.28	33.40	0.40	32.98	0.98	34.50	0.00	35.00	0.00	32.82	1.12	35.50	0.00
0.29	33.41	0.41	33.05	1.05	34.50	0.00	35.00	0.00	32.87	1.17	35.50	0.00
0.30	33.42	0.42	33.11	1.11	34.50	0.00	35.00	0.00	32.92	1.22	35.50	0.00
0.31	33.43	0.43	33.18	1.18	34.50	0.00	35.00	0.00	32.96	1.26	35.50	0.00
0.32	33.43	0.43	33.24	1.24	34.50	0.00	35.00	0.00	33.00	1.30	35.50	0.00
0.33	33.44	0.44	33.30	1.30	34.50	0.00	35.00	0.00	33.05	1.35	35.50	0.00
0.34	33.45	0.45	33.37	1.37	34.50	0.00	35.00	0.00	33.09	1.39	35.50	0.00
0.35	33.46	0.46	33.43	1.43	34.50	0.00	35.00	0.00	33.14	1.44	35.50	0.00
0.36	33.47	0.47	33.50	1.50	34.50	0.00	35.00	0.00	33.18	1.48	35.50	0.00
0.37	33.51	0.51	33.55	1.55	34.50	0.00	35.00	0.00	33.22	1.52	35.50	0.00
0.38	33.58	0.58	33.60	1.60	34.50	0.00	35.00	0.00	33.26	1.56	35.50	0.00
0.39	33.66	0.66	33.67	1.67	34.50	0.00	35.00	0.00	33.30	1.60	35.50	0.00
0.40	33.75	0.75	33.75	1.75	34.50	0.00	35.00	0.00	33.36	1.66	35.50	0.00
0.41	33.85	0.85	33.84	1.84	34.50	0.00	35.00	0.00	33.44	1.74	35.50	0.00
0.42	33.98	0.98	33.96	1.96	34.50	0.00	35.00	0.00	33.53	1.83	35.50	0.00
0.43	34.15	1.15	34.11	2.00	34.50	0.00	35.00	0.00	33.64	1.94	35.50	0.00
0.44	34.36	1.36	34.31	2.00	34.50	0.00	35.00	0.00	33.79	2.00	35.50	0.00
0.45	34.63	1.50	34.55	2.00	34.52	0.02	35.00	0.00	33.98	2.00	35.50	0.00
0.46	34.84	1.50	34.76	2.00	34.75	0.25	35.00	0.00	34.14	2.00	35.50	0.00
0.47	35.07	1.50	34.99	2.00	34.99	0.49	35.00	0.00	34.32	2.00	35.50	0.00
0.48	35.33	1.50	35.25	2.00	35.25	0.75	35.00	0.00	34.51	2.00	35.50	0.00
0.49	35.62	1.50	35.54	2.00	35.54	1.04	35.00	0.00	34.72	2.00	35.50	0.00
0.50	35.92	1.50	35.84	2.00	35.84	1.34	35.00	0.00	34.95	2.00	35.50	0.00
0.51	36.19	1.50	36.08	2.00	36.06	1.56	35.08	0.08	35.08	2.00	35.50	0.00
0.52	36.25	1.50	36.15	2.00	36.13	1.63	35.20	0.20	35.19	2.00	35.50	0.00
0.53	36.28	1.50	36.18	2.00	36.17	1.67	35.32	0.32	35.31	2.00	35.50	0.00
0.54	36.31	1.50	36.21	2.00	36.18	1.68	35.43	0.43	35.42	2.00	35.50	0.00
0.55	36.34	1.50	36.23	2.00	36.20	1.70	35.53	0.53	35.52	2.00	35.51	0.01
0.56	36.36	1.50	36.25	2.00	36.21	1.71	35.63	0.63	35.62	2.00	35.62	0.12
0.57	36.38	1.50	36.27	2.00	36.22	1.72	35.72	0.72	35.71	2.00	35.70	0.20
0.58	36.41	1.50	36.29	2.00	36.23	1.73	35.80	0.80	35.79	2.00	35.75	0.25
0.59	36.43	1.50	36.30	2.00	36.24	1.74	35.87	0.87	35.85	2.00	35.79	0.29
1. 0	36.45	1.50	36.32	2.00	36.25	1.75	35.93	0.93	35.91	2.00	35.83	0.33
1. 1	36.46	1.50	36.34	2.00	36.26	1.76	35.97	0.97	35.95	2.00	35.86	0.36
1. 2	36.48	1.50	36.35	2.00	36.26	1.76	36.01	1.01	35.99	2.00	35.89	0.39
1. 3	36.50	1.50	36.36	2.00	36.27	1.77	36.04	1.04	36.02	2.00	35.91	0.41
1. 4	36.51	1.50	36.38	2.00	36.27	1.77	36.07	1.07	36.05	2.00	35.93	0.43

1. 5	36.52	1.50	36.39	2.00	36.28	1.78	36.09	1.09	36.07	2.00	35.94	0.44
1. 6	36.54	1.50	36.40	2.00	36.28	1.78	36.11	1.11	36.09	2.00	35.95	0.45
1. 7	36.57	1.50	36.44	2.00	36.29	1.79	36.13	1.13	36.11	2.00	35.96	0.46
1. 8	36.60	1.50	36.46	2.00	36.30	1.80	36.16	1.16	36.14	2.00	35.98	0.48
1. 9	36.61	1.50	36.47	2.00	36.30	1.80	36.19	1.19	36.16	2.00	36.00	0.50
1.10	36.62	1.50	36.48	2.00	36.31	1.81	36.21	1.21	36.18	2.00	36.01	0.51
1.11	36.64	1.50	36.49	2.00	36.32	1.82	36.22	1.22	36.19	2.00	36.02	0.52
1.12	36.65	1.50	36.50	2.00	36.33	1.83	36.23	1.23	36.20	2.00	36.03	0.53
1.13	36.66	1.50	36.51	2.00	36.34	1.84	36.23	1.23	36.21	2.00	36.03	0.53
1.14	36.67	1.50	36.52	2.00	36.34	1.84	36.24	1.24	36.21	2.00	36.03	0.53
1.15	36.67	1.50	36.52	2.00	36.35	1.85	36.25	1.25	36.22	2.00	36.04	0.54
1.16	36.68	1.50	36.53	2.00	36.35	1.85	36.25	1.25	36.22	2.00	36.04	0.54
1.17	36.69	1.50	36.54	2.00	36.36	1.86	36.25	1.25	36.23	2.00	36.04	0.54
1.18	36.70	1.50	36.54	2.00	36.36	1.86	36.26	1.26	36.23	2.00	36.04	0.54
1.19	36.70	1.50	36.55	2.00	36.37	1.87	36.26	1.26	36.23	2.00	36.05	0.55
1.20	36.70	1.50	36.55	2.00	36.37	1.87	36.26	1.26	36.24	2.00	36.05	0.55
1.21	36.70	1.50	36.55	2.00	36.37	1.87	36.27	1.27	36.24	2.00	36.05	0.55
1.22	36.70	1.50	36.55	2.00	36.37	1.87	36.27	1.27	36.24	2.00	36.05	0.55
1.23	36.70	1.50	36.55	2.00	36.37	1.87	36.27	1.27	36.24	2.00	36.05	0.55
1.24	36.70	1.50	36.55	2.00	36.37	1.87	36.27	1.27	36.24	2.00	36.05	0.55
1.25	36.69	1.50	36.54	2.00	36.37	1.87	36.27	1.27	36.24	2.00	36.05	0.55
1.26	36.68	1.50	36.53	2.00	36.37	1.87	36.26	1.26	36.23	2.00	36.05	0.55
1.27	36.67	1.50	36.53	2.00	36.36	1.86	36.26	1.26	36.23	2.00	36.05	0.55
1.28	36.66	1.50	36.51	2.00	36.36	1.86	36.26	1.26	36.22	2.00	36.04	0.54
1.29	36.64	1.50	36.50	2.00	36.35	1.85	36.25	1.25	36.22	2.00	36.04	0.54
1.30	36.62	1.50	36.48	2.00	36.34	1.84	36.24	1.24	36.21	2.00	36.03	0.53
1.31	36.58	1.50	36.44	2.00	36.32	1.82	36.22	1.22	36.19	2.00	36.03	0.53
1.32	36.53	1.50	36.38	2.00	36.29	1.79	36.20	1.20	36.16	2.00	36.01	0.51
1.33	36.48	1.50	36.33	2.00	36.27	1.77	36.15	1.15	36.12	2.00	35.98	0.48
1.34	36.43	1.50	36.29	2.00	36.25	1.75	36.09	1.09	36.06	2.00	35.95	0.45
1.35	36.38	1.50	36.25	2.00	36.23	1.73	36.03	1.03	36.00	2.00	35.91	0.41
1.36	36.35	1.50	36.22	2.00	36.21	1.71	35.96	0.96	35.94	2.00	35.87	0.37
1.37	36.36	1.50	36.23	2.00	36.20	1.70	35.90	0.90	35.88	2.00	35.83	0.33
1.38	36.37	1.50	36.24	2.00	36.21	1.71	35.87	0.87	35.86	2.00	35.80	0.30
1.39	36.39	1.50	36.26	2.00	36.22	1.72	35.86	0.86	35.85	2.00	35.80	0.30
1.40	36.41	1.50	36.28	2.00	36.23	1.73	35.88	0.88	35.86	2.00	35.80	0.30
1.41	36.42	1.50	36.30	2.00	36.24	1.74	35.90	0.90	35.89	2.00	35.82	0.32
1.42	36.44	1.50	36.32	2.00	36.25	1.75	35.94	0.94	35.92	2.00	35.84	0.34
1.43	36.45	1.50	36.32	2.00	36.26	1.76	35.97	0.97	35.95	2.00	35.86	0.36
1.44	36.45	1.50	36.33	2.00	36.26	1.76	36.00	1.00	35.98	2.00	35.88	0.38
1.45	36.45	1.50	36.33	2.00	36.26	1.76	36.02	1.02	35.99	2.00	35.89	0.39
1.46	36.45	1.50	36.33	2.00	36.26	1.76	36.03	1.03	36.00	2.00	35.90	0.40
1.47	36.45	1.50	36.33	2.00	36.26	1.76	36.03	1.03	36.01	2.00	35.90	0.40
1.48	36.45	1.50	36.33	2.00	36.26	1.76	36.04	1.04	36.01	2.00	35.91	0.41
1.49	36.45	1.50	36.33	2.00	36.26	1.76	36.04	1.04	36.01	2.00	35.91	0.41
1.50	36.45	1.50	36.33	2.00	36.26	1.76	36.04	1.04	36.01	2.00	35.91	0.41
1.51	36.45	1.50	36.33	2.00	36.26	1.76	36.04	1.04	36.01	2.00	35.91	0.41
1.52	36.44	1.50	36.33	2.00	36.26	1.76	36.03	1.03	36.01	2.00	35.91	0.41
1.53	36.44	1.50	36.32	2.00	36.26	1.76	36.03	1.03	36.01	2.00	35.91	0.41
1.54	36.44	1.50	36.32	2.00	36.26	1.76	36.03	1.03	36.01	2.00	35.90	0.40
1.55	36.43	1.50	36.32	2.00	36.25	1.75	36.03	1.03	36.01	2.00	35.90	0.40
1.56	36.42	1.50	36.31	2.00	36.25	1.75	36.02	1.02	36.00	2.00	35.90	0.40
1.57	36.41	1.50	36.30	2.00	36.25	1.75	36.01	1.01	35.99	2.00	35.89	0.39
1.58	36.40	1.50	36.29	2.00	36.24	1.74	36.00	1.00	35.97	2.00	35.88	0.38
1.59	36.39	1.50	36.28	2.00	36.24	1.74	35.98	0.98	35.96	2.00	35.87	0.37

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DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

''''''''''''''''' SUMMARY STATISTICS FOR JUNCTIONS '''''''''''''''''

JUNCTION NUMBER	GROUND ELEVATION (FT)	UPPERMOST PIPE CROWN ELEVATION (FT)	MAXIMUM COMPUTED DEPTH (FT)	TIME OF OCCURENCE HR.	TIME OF OCCURENCE MIN.	FEET OF SURCHARGE AT MAX. DEPTH	FEET MAX. DEPTH IS BELOW GROUND ELEVATION	LENGTH OF SURCHARGE (MIN)
1	22.15	22.15	4.27	2	0	0.00	5.73	0.0
2	22.10	22.10	4.10	2	0	0.00	5.90	0.0
3	22.05	22.05	3.88	2	0	0.00	6.12	0.0
4	22.00	22.00	3.71	2	0	0.00	6.29	0.0
5	21.95	21.95	3.50	2	0	0.00	6.50	0.0
6	21.90	21.90	3.19	2	0	0.00	6.81	0.0
7	21.85	21.85	1.96	2	0	0.00	8.04	0.0
8	15.50	15.50	3.00	1	10	0.00	0.00	0.0
9	29.00	29.00	0.24	1	24	0.00	2.76	0.0
10	34.00	34.00	0.75	1	24	0.00	1.25	0.0
11	37.50	37.50	0.55	1	23	0.00	1.45	0.0
1012	37.00	37.00	1.27	1	23	0.00	0.73	0.0
35	21.61	21.60	1.15	1	21	0.00	0.46	0.0
14	26.61	26.60	1.00	1	21	0.00	0.61	0.0
13	30.40	30.40	0.41	1	23	0.00	0.59	0.0
34	32.50	32.50	0.39	1	23	0.00	0.61	0.0
12	47.00	33.70	4.54	1	23	2.54	10.76	76.5
18	37.00	34.00	4.55	1	22	2.55	0.45	77.7
17	38.00	34.50	3.70	1	22	2.20	1.30	75.3
16	41.00	37.50	0.89	1	21	0.00	4.11	0.0
15	44.00	41.50	0.51	1	17	0.00	3.49	0.0
20	39.00	36.70	2.82	1	21	2.12	0.18	25.0
22	43.00	39.70	2.10	1	21	1.40	1.90	10.3
25	57.50	44.70	0.42	1	21	0.00	13.08	0.0
36	58.80	47.00	1.10	1	21	0.00	12.70	0.0
19	29.60	29.60	0.89	1	20	0.00	0.71	0.0
21	33.60	33.60	0.99	1	20	0.00	0.61	0.0
23	35.60	35.60	1.21	1	20	0.00	0.39	0.0
24	43.60	43.60	0.79	1	19	0.00	0.81	0.0
26	44.60	44.60	1.59	1	19	0.00	0.01	0.0
30	50.00	45.60	1.05	1	19	0.00	4.95	0.0
29	60.00	47.00	3.90	1	19	1.90	11.10	65.5
28	52.50	50.50	0.53	1	7	0.00	2.97	0.0
27	55.00	52.50	0.84	1	7	0.00	3.16	0.0
31	52.60	52.60	0.78	1	19	0.00	0.82	0.0
32	56.60	56.60	0.95	1	18	0.00	0.65	0.0
33	61.60	61.60	0.81	1	18	0.00	0.79	0.0
1025	48.50	48.50	0.00	0	0	0.00	1.00	0.0

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

''''''''''''''''' SUMMARY STATISTICS FOR JUNCTIONS '''''''''''''''''

JUNCTION NUMBER	GROUND ELEVATION (FT)	UPPERMOST PIPE CROWN ELEVATION (FT)	MAXIMUM COMPUTED DEPTH (FT)	TIME OF OCCURENCE HR.	MIN.	FEET OF SURCHARGE AT MAX. DEPTH	FEET MAX. DEPTH IS BELOW GROUND ELEVATION	LENGTH OF SURCHARGE (MIN)
1036	49.30	49.30	0.39	1	19	0.00	1.61	0.0
1029	50.00	50.00	0.86	1	19	0.00	1.14	0.0
1018	36.50	36.50	1.87	1	23	0.00	0.13	0.0
1020	40.00	40.00	0.00	0	0	0.00	1.00	0.0
1022	44.00	44.00	0.00	0	0	0.00	1.00	0.0

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ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

*************** TIME HISTORY OF FLOW AND VELOCITY ***************

Q(CFS), VEL(FPS)

TIME	CONDUIT 29		CONDUIT 31		CONDUIT 30		CONDUIT 1036		CONDUIT 1026		CONDUIT 1019	
HR . MIN	FLOW	VEL	FLOW	VEL	FLOW	VEL	FLOW	VEL	FLOW	VEL	FLOW	VEL
0.20	0.14	0.6	1.36	1.5	1.33	4.0	0.00	0.0	0.00	0.0	0.00	0.0
0.21	0.15	0.6	1.54	1.6	1.51	4.2	0.00	0.0	0.00	0.0	0.00	0.0
0.22	0.16	0.6	1.71	1.6	1.69	4.3	0.00	0.0	0.00	0.0	0.00	0.0
0.23	0.17	0.6	1.88	1.6	1.88	4.4	0.00	0.0	0.00	0.0	0.00	0.0
0.24	0.18	0.6	2.05	1.7	2.07	4.5	0.00	0.0	0.00	0.0	0.00	0.0
0.25	0.20	0.6	2.23	1.7	2.25	4.6	0.00	0.0	0.00	0.0	0.00	0.0
0.26	0.21	0.6	2.43	1.8	2.45	4.7	0.00	0.0	0.00	0.0	0.00	0.0
0.27	0.23	0.6	2.64	1.8	2.67	4.8	0.00	0.0	0.00	0.0	0.00	0.0
0.28	0.25	0.6	2.84	1.8	2.89	4.9	0.00	0.0	0.00	0.0	0.00	0.0
0.29	0.27	0.6	3.04	1.8	3.11	5.0	0.00	0.0	0.00	0.0	0.00	0.0
0.30	0.28	0.6	3.25	1.9	3.33	5.1	0.00	0.0	0.00	0.0	0.00	0.0
0.31	0.30	0.6	3.46	1.9	3.55	5.2	0.00	0.0	0.00	0.0	0.00	0.0
0.32	0.32	0.6	3.69	1.9	3.78	5.2	0.00	0.0	0.00	0.0	0.00	0.0
0.33	0.33	0.6	3.93	1.9	4.03	5.3	0.00	0.0	0.00	0.0	0.00	0.0
0.34	0.35	0.6	4.17	2.0	4.28	5.4	0.00	0.0	0.00	0.0	0.00	0.0
0.35	0.37	0.6	4.40	2.0	4.53	5.5	0.00	0.0	0.00	0.0	0.00	0.0
0.36	0.38	0.6	4.64	2.0	4.78	5.5	0.00	0.0	0.00	0.0	0.00	0.0
0.37	0.41	0.6	4.89	2.0	5.04	5.6	0.00	0.0	0.00	0.0	0.00	0.0
0.38	0.45	0.7	5.16	2.0	5.32	5.7	0.00	0.0	0.00	0.0	0.00	0.0
0.39	0.48	0.7	5.43	2.0	5.62	5.8	0.00	0.0	0.00	0.0	0.00	0.0
0.40	0.52	0.7	5.70	2.0	5.91	5.8	0.00	0.0	0.00	0.0	0.00	0.0
0.41	0.55	0.7	5.96	2.0	6.21	5.9	0.00	0.0	0.00	0.0	0.00	0.0
0.42	0.59	0.7	6.23	2.0	6.51	6.0	0.00	0.0	0.00	0.0	0.00	0.0
0.43	0.74	0.9	6.51	2.0	6.85	6.1	0.00	0.0	0.00	0.0	0.00	0.0
0.44	0.95	1.0	6.82	2.0	7.28	6.2	0.00	0.0	0.00	0.0	0.00	0.0
0.45	1.16	1.2	7.12	1.9	7.75	6.3	0.00	0.0	0.00	0.0	0.00	0.0
0.46	1.36	1.3	7.42	1.9	8.23	6.4	0.00	0.0	0.00	0.0	0.00	0.0
0.47	1.56	1.5	7.72	1.8	8.69	6.5	0.00	0.0	0.00	0.0	0.00	0.0
0.48	1.76	1.6	8.02	1.8	9.20	6.6	0.00	0.0	0.00	0.0	0.00	0.0
0.49	1.94	1.7	8.34	1.7	9.74	6.9	0.00	0.0	0.00	0.0	0.00	0.0
0.50	2.11	1.8	8.68	1.8	10.25	7.1	0.00	0.0	0.00	0.0	0.00	0.0
0.51	2.29	1.9	9.01	1.8	10.75	7.2	0.00	0.0	0.00	0.0	0.00	0.0
0.52	2.46	2.0	9.35	1.8	11.24	7.4	0.00	0.0	0.00	0.0	0.00	0.0
0.53	2.63	2.1	9.68	1.8	11.70	7.6	0.00	0.0	0.00	0.0	0.00	0.0
0.54	2.81	2.2	10.02	1.8	12.09	7.8	0.00	0.0	0.00	0.0	0.00	0.0
0.55	2.98	2.2	10.39	1.8	12.52	7.9	0.00	0.0	0.00	0.0	0.00	0.0
0.56	3.15	2.3	10.81	1.7	13.21	8.2	0.00	0.0	0.00	0.0	0.00	0.0
0.57	3.33	2.3	11.22	1.7	14.06	8.7	0.00	0.0	0.00	0.0	0.00	0.0
0.58	3.50	2.4	11.64	1.7	14.71	9.1	0.00	0.0	0.00	0.0	0.00	0.0
0.59	3.67	2.5	12.06	1.8	15.32	9.4	0.00	0.0	0.00	0.0	0.00	0.0
1. 0	3.85	2.6	12.48	1.8	15.86	9.7	0.00	0.0	0.00	0.0	0.00	0.0
1. 1	4.02	2.8	12.88	1.9	16.34	10.0	0.00	0.0	0.00	0.0	0.00	0.0
1. 2	4.19	2.9	13.25	1.9	16.88	10.3	0.00	0.0	0.00	0.0	0.00	0.0
1. 3	4.37	3.0	13.61	2.0	17.43	10.6	0.00	0.0	0.00	0.0	0.00	0.0
1. 4	4.54	3.1	13.98	2.0	17.91	10.8	0.09	0.4	0.00	0.0	0.00	0.0
1. 5	4.71	3.2	14.35	2.1	18.24	11.0	0.40	0.8	0.00	0.0	0.00	0.0
1. 6	4.89	3.3	14.72	2.1	18.47	11.2	0.82	1.0	0.00	0.0	0.00	0.0

1, 7	4.90	3.3	14.95	2.2	18.59	11.2	1.14	1.1	0.00	0.0	0.00	0.0
1, 8	4.90	3.3	15.03	2.2	18.63	11.3	1.25	1.2	0.00	0.0	0.00	0.0
1, 9	4.90	3.3	15.11	2.2	18.66	11.3	1.31	1.2	0.00	0.0	0.00	0.0
1,10	4.89	3.3	15.19	2.2	18.68	11.3	1.37	1.2	0.00	0.0	0.00	0.0
1,11	4.89	3.3	15.28	2.2	18.70	11.3	1.43	1.2	0.00	0.0	0.00	0.0
1,12	4.89	3.3	15.36	2.2	18.72	11.3	1.49	1.2	0.00	0.0	0.00	0.0
1,13	4.89	3.3	15.44	2.2	18.74	11.3	1.55	1.3	0.00	0.0	0.00	0.0
1,14	4.89	3.3	15.53	2.2	18.76	11.3	1.61	1.3	0.00	0.0	0.00	0.0
1,15	4.89	3.3	15.61	2.3	18.79	11.3	1.67	1.3	0.00	0.0	0.00	0.0
1,16	4.88	3.3	15.69	2.3	18.81	11.4	1.73	1.3	0.00	0.0	0.00	0.0
1,17	4.88	3.3	15.78	2.3	18.83	11.4	1.79	1.3	0.00	0.0	0.00	0.0
1,18	4.88	3.3	15.86	2.3	18.85	11.4	1.85	1.3	0.00	0.0	0.00	0.0
1,19	4.88	3.3	15.85	2.3	18.86	11.4	1.89	1.3	0.00	0.0	0.00	0.0
1,20	4.88	3.3	15.72	2.3	18.83	11.4	1.83	1.3	0.00	0.0	0.00	0.0
1,21	4.88	3.3	15.61	2.3	18.80	11.4	1.74	1.3	0.00	0.0	0.00	0.0
1,22	4.87	3.3	15.49	2.2	18.76	11.3	1.65	1.3	0.00	0.0	0.00	0.0
1,23	4.87	3.3	15.37	2.2	18.73	11.3	1.56	1.3	0.00	0.0	0.00	0.0
1,24	4.87	3.3	15.26	2.2	18.70	11.3	1.47	1.2	0.00	0.0	0.00	0.0
1,25	4.87	3.3	15.10	2.2	18.67	11.3	1.38	1.2	0.00	0.0	0.00	0.0
1,26	4.87	3.3	14.90	2.2	18.62	11.3	1.25	1.2	0.00	0.0	0.00	0.0
1,27	4.87	3.3	14.70	2.1	18.56	11.2	1.11	1.2	0.00	0.0	0.00	0.0
1,28	4.86	3.3	14.50	2.1	18.50	11.2	0.97	1.1	0.00	0.0	0.00	0.0
1,29	4.86	3.3	14.30	2.1	18.44	11.2	0.84	1.1	0.00	0.0	0.00	0.0
1,30	4.86	3.3	14.10	2.1	18.37	11.1	0.69	1.0	0.00	0.0	0.00	0.0
1,31	4.24	3.0	13.92	2.0	18.20	11.0	0.39	0.9	0.00	0.0	0.00	0.0
1,32	3.58	2.6	13.75	2.0	17.86	10.9	0.06	0.7	0.00	0.0	0.00	0.0
1,33	2.92	2.1	13.58	2.0	17.24	10.6	0.00	0.0	0.00	0.0	0.00	0.0
1,34	2.26	1.7	13.42	2.0	16.49	10.2	0.00	0.0	0.00	0.0	0.00	0.0
1,35	1.60	1.2	13.25	1.9	15.60	9.7	0.00	0.0	0.00	0.0	0.00	0.0
1,36	0.98	0.8	13.09	1.9	14.68	9.2	0.00	0.0	0.00	0.0	0.00	0.0
1,37	1.25	0.9	12.96	1.9	14.21	8.9	0.00	0.0	0.00	0.0	0.00	0.0
1,38	1.76	1.2	12.88	1.9	14.40	8.9	0.00	0.0	0.00	0.0	0.00	0.0
1,39	2.27	1.6	12.79	1.9	14.79	9.1	0.00	0.0	0.00	0.0	0.00	0.0
1,40	2.78	1.9	12.71	1.9	15.20	9.4	0.00	0.0	0.00	0.0	0.00	0.0
1,41	3.28	2.2	12.63	1.9	15.62	9.6	0.00	0.0	0.00	0.0	0.00	0.0
1,42	3.78	2.6	12.54	1.8	15.96	9.8	0.00	0.0	0.00	0.0	0.00	0.0
1,43	3.82	2.7	12.46	1.8	16.19	9.9	0.00	0.0	0.00	0.0	0.00	0.0
1,44	3.81	2.6	12.38	1.8	16.21	10.0	0.00	0.0	0.00	0.0	0.00	0.0
1,45	3.81	2.6	12.29	1.8	16.17	9.9	0.00	0.0	0.00	0.0	0.00	0.0
1,46	3.81	2.6	12.21	1.8	16.10	9.9	0.00	0.0	0.00	0.0	0.00	0.0
1,47	3.80	2.6	12.13	1.8	16.02	9.8	0.00	0.0	0.00	0.0	0.00	0.0
1,48	3.80	2.6	12.04	1.8	15.93	9.8	0.00	0.0	0.00	0.0	0.00	0.0
1,49	3.80	2.6	11.96	1.8	15.85	9.8	0.00	0.0	0.00	0.0	0.00	0.0
1,50	3.79	2.6	11.88	1.7	15.75	9.7	0.00	0.0	0.00	0.0	0.00	0.0
1,51	3.79	2.6	11.79	1.7	15.66	9.7	0.00	0.0	0.00	0.0	0.00	0.0
1,52	3.79	2.6	11.71	1.7	15.57	9.6	0.00	0.0	0.00	0.0	0.00	0.0
1,53	3.78	2.6	11.63	1.7	15.48	9.6	0.00	0.0	0.00	0.0	0.00	0.0
1,54	3.78	2.6	11.54	1.7	15.39	9.5	0.00	0.0	0.00	0.0	0.00	0.0
1,55	3.63	2.5	11.46	1.7	15.23	9.4	0.00	0.0	0.00	0.0	0.00	0.0
1,56	3.46	2.4	11.38	1.7	15.01	9.3	0.00	0.0	0.00	0.0	0.00	0.0
1,57	3.29	2.3	11.30	1.7	14.76	9.2	0.00	0.0	0.00	0.0	0.00	0.0
1,58	3.12	2.2	11.21	1.7	14.51	9.0	0.00	0.0	0.00	0.0	0.00	0.0
1,59	2.95	2.1	11.13	1.6	14.26	8.9	0.00	0.0	0.00	0.0	0.00	0.0

FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

**************** TIME HISTORY OF FLOW AND VELOCITY ***************

Q(CFS), VEL(FPS)

TIME	CONDUIT 17		CONDUIT 19		CONDUIT 14		CONDUIT 12		CONDUIT 11		CONDUIT 1014	
HR . MIN	FLOW	VEL	FLOW	VEL	FLOW	VEL	FLOW	VEL	FLOW	VEL	FLOW	VEL
0.20	1.13	2.8	0.00	0.0	1.19	2.1	1.11	3.0	0.00	0.0	0.00	0.0
0.21	1.22	2.7	0.00	0.0	1.28	2.2	1.21	3.0	0.00	0.0	0.00	0.0
0.22	1.30	2.7	0.00	0.0	1.37	2.2	1.30	3.1	0.00	0.0	0.00	0.0
0.23	1.39	2.6	0.00	0.0	1.46	2.2	1.39	3.2	0.00	0.0	0.00	0.0
0.24	1.47	2.6	0.00	0.0	1.56	2.2	1.49	3.3	0.00	0.0	0.00	0.0
0.25	1.55	2.5	0.00	0.0	1.64	2.3	1.57	3.4	0.00	0.0	0.00	0.0
0.26	1.64	2.4	0.00	0.0	1.73	2.3	1.67	3.4	0.00	0.0	0.00	0.0
0.27	1.72	2.4	0.00	0.0	1.82	2.3	1.76	3.6	0.00	0.0	0.00	0.0
0.28	1.81	2.3	0.00	0.0	1.93	2.4	1.87	3.7	0.00	0.0	0.00	0.0
0.29	1.89	2.2	0.00	0.0	2.04	2.6	1.98	3.8	0.00	0.0	0.00	0.0
0.30	1.97	2.2	0.00	0.0	2.15	2.7	2.09	3.9	0.00	0.0	0.00	0.0
0.31	2.06	2.2	0.00	0.0	2.25	2.8	2.19	4.0	0.00	0.0	0.00	0.0
0.32	2.14	2.1	0.00	0.0	2.36	3.0	2.30	4.1	0.00	0.0	0.00	0.0
0.33	2.23	2.1	0.00	0.0	2.46	3.1	2.40	4.2	0.00	0.0	0.00	0.0
0.34	2.31	2.1	0.00	0.0	2.56	3.2	2.50	4.3	0.00	0.0	0.00	0.0
0.35	2.39	2.1	0.00	0.0	2.66	3.4	2.60	4.4	0.00	0.0	0.00	0.0
0.36	2.48	2.1	0.00	0.0	2.75	3.5	2.70	4.5	0.00	0.0	0.00	0.0
0.37	2.41	2.0	0.00	0.0	2.79	3.6	2.78	4.5	0.00	0.0	0.00	0.0
0.38	2.48	1.9	0.00	0.0	2.87	3.7	2.84	4.6	0.00	0.0	0.00	0.0
0.39	2.56	1.9	0.00	0.0	2.96	3.8	2.91	4.7	0.00	0.0	0.00	0.0
0.40	2.64	1.8	0.00	0.0	3.04	3.9	2.98	4.7	0.00	0.0	0.00	0.0
0.41	2.69	1.8	0.00	0.0	3.09	3.9	3.01	4.7	0.00	0.0	0.00	0.0
0.42	2.77	1.7	0.00	0.0	3.17	4.0	3.10	4.9	0.00	0.0	0.00	0.0
0.43	2.78	1.7	0.00	0.0	3.33	4.2	3.20	5.0	0.00	0.0	0.00	0.0
0.44	2.83	1.6	0.00	0.0	3.51	4.4	3.35	5.2	0.00	0.0	0.00	0.0
0.45	2.93	1.6	0.00	0.0	3.69	4.7	3.53	5.5	0.00	0.0	0.00	0.0
0.46	3.03	1.7	0.00	0.0	3.83	4.8	3.68	5.7	0.00	0.0	0.00	0.0
0.47	3.08	1.7	0.00	0.0	4.00	5.1	3.84	5.9	0.00	0.0	0.00	0.0
0.48	3.12	1.8	0.00	0.0	4.19	5.3	4.00	6.2	0.00	0.0	0.00	0.0
0.49	3.17	1.8	0.00	0.0	4.40	5.6	4.19	6.4	0.00	0.0	0.00	0.0
0.50	3.23	1.8	0.00	0.0	4.60	5.8	4.38	6.7	0.00	0.0	0.00	0.0
0.51	3.54	1.9	-0.08	-0.2	4.89	6.2	4.50	6.9	0.00	0.0	0.08	0.1
0.52	3.60	2.0	-0.02	-0.1	4.81	6.1	4.59	7.0	0.00	0.0	0.82	0.6
0.53	3.70	2.1	-0.02	-0.0	4.58	5.9	4.69	7.2	0.00	0.0	1.51	0.5
0.54	3.77	2.1	-0.02	-0.1	4.35	5.6	4.78	7.3	0.00	0.0	2.00	0.4
0.55	3.84	2.2	-0.01	-0.0	4.13	5.3	4.86	7.4	-0.05	-0.0	2.50	0.4
0.56	3.91	2.2	-0.02	-0.1	3.91	5.0	4.93	7.5	-0.14	-0.2	2.94	0.4
0.57	3.98	2.2	-0.01	-0.0	3.70	4.8	5.00	7.6	-0.33	-0.3	3.41	0.4
0.58	4.04	2.3	-0.02	-0.1	3.49	4.5	5.07	7.7	-0.68	-0.5	3.85	0.4
0.59	4.06	2.3	-0.00	-0.0	3.31	4.2	5.12	7.8	-1.15	-0.7	4.27	0.4
1. 0	4.14	2.3	-0.02	-0.1	3.16	4.1	5.16	7.8	-1.55	-0.9	4.65	0.5
1. 1	4.18	2.4	-0.00	-0.0	3.04	3.9	5.20	7.9	-1.93	-1.0	5.02	0.5
1. 2	4.22	2.4	-0.02	-0.0	2.94	3.8	5.23	7.9	-2.29	-1.0	5.33	0.5
1. 3	4.25	2.4	-0.00	-0.0	2.87	3.7	5.25	8.0	-2.61	-1.1	5.61	0.5
1. 4	4.29	2.4	-0.01	-0.0	2.81	3.6	5.27	8.0	-2.89	-1.2	5.88	0.6
1. 5	4.32	2.4	-0.01	-0.0	2.77	3.5	5.29	8.0	-3.15	-1.2	6.12	0.6
1. 6	4.36	2.5	-0.01	-0.0	2.73	3.5	5.30	8.0	-3.39	-1.3	6.36	0.6

1. 7	4.27	2.4	0.78	1.6	2.80	3.5	5.32	8.1	-3.62	-1.3	6.71	0.6
1. 8	4.39	2.5	0.99	2.4	2.76	3.5	5.34	8.1	-4.02	-1.4	7.23	0.7
1. 9	4.45	2.5	1.19	3.0	2.71	3.5	5.36	8.1	-4.42	-1.4	7.64	0.7
1.10	4.50	2.5	1.27	3.3	2.66	3.4	5.38	8.1	-4.71	-1.5	7.68	0.7
1.11	4.52	2.6	1.33	3.4	2.66	3.4	5.38	8.2	-4.85	-1.5	7.77	0.7
1.12	4.56	2.6	1.38	3.6	2.68	3.4	5.39	8.2	-4.98	-1.5	7.86	0.7
1.13	4.58	2.6	1.44	3.7	2.69	3.4	5.40	8.2	-5.09	-1.5	7.95	0.7
1.14	4.58	2.6	1.47	3.8	2.69	3.4	5.40	8.2	-5.19	-1.5	8.01	0.7
1.15	4.58	2.6	1.50	3.9	2.70	3.4	5.41	8.2	-5.26	-1.5	8.06	0.7
1.16	4.58	2.6	1.54	3.9	2.70	3.4	5.41	8.2	-5.32	-1.5	8.11	0.7
1.17	4.57	2.6	1.66	4.3	2.72	3.5	5.41	8.2	-5.39	-1.5	8.17	0.7
1.18	4.58	2.6	1.72	4.4	2.73	3.5	5.41	8.2	-5.46	-1.6	8.23	0.7
1.19	4.58	2.6	1.73	4.5	2.73	3.5	5.42	8.2	-5.52	-1.6	8.28	0.7
1.20	4.56	2.6	1.77	4.6	2.74	3.5	5.42	8.2	-5.57	-1.6	8.30	0.7
1.21	4.55	2.6	1.80	4.7	2.74	3.5	5.42	8.2	-5.60	-1.6	8.33	0.8
1.22	4.54	2.6	1.79	4.7	2.74	3.5	5.42	8.2	-5.63	-1.6	8.34	0.8
1.23	4.53	2.6	1.75	4.6	2.73	3.5	5.42	8.2	-5.64	-1.6	8.34	0.8
1.24	4.51	2.6	1.73	4.5	2.72	3.5	5.42	8.2	-5.63	-1.6	8.32	0.7
1.25	4.51	2.6	1.62	4.3	2.70	3.4	5.42	8.2	-5.61	-1.6	8.28	0.7
1.26	4.50	2.5	1.51	3.9	2.68	3.4	5.42	8.2	-5.56	-1.6	8.21	0.7
1.27	4.48	2.5	1.46	3.8	2.67	3.4	5.42	8.2	-5.49	-1.6	8.15	0.7
1.28	4.50	2.5	1.17	3.2	2.62	3.3	5.41	8.2	-5.42	-1.6	8.06	0.7
1.29	4.47	2.5	1.02	2.7	2.59	3.3	5.40	8.2	-5.29	-1.5	7.91	0.7
1.30	4.47	2.5	0.88	2.3	2.56	3.3	5.40	8.2	-5.14	-1.5	7.78	0.7
1.31	4.54	2.6	0.75	2.0	2.43	3.1	5.39	8.2	-4.93	-1.5	7.47	0.7
1.32	4.54	2.6	0.61	1.7	2.30	3.0	5.37	8.1	-4.56	-1.4	6.77	0.7
1.33	4.52	2.6	0.38	1.2	2.26	2.9	5.33	8.1	-3.85	-1.3	5.71	0.6
1.34	4.48	2.5	0.13	0.5	2.30	2.9	5.29	8.0	-3.11	-1.2	4.73	0.5
1.35	4.38	2.5	0.04	0.1	2.41	3.0	5.24	8.0	-2.39	-1.1	3.80	0.4
1.36	4.32	2.5	0.06	0.2	2.56	3.2	5.19	7.9	-1.76	-0.9	2.94	0.3
1.37	4.28	2.4	-0.03	-0.1	2.83	3.6	5.15	7.8	-1.30	-0.8	2.66	0.3
1.38	4.25	2.4	0.03	0.1	3.02	3.8	5.13	7.8	-1.10	-0.7	2.86	0.3
1.39	4.23	2.4	-0.03	-0.0	3.11	3.9	5.12	7.8	-1.08	-0.7	3.20	0.3
1.40	4.21	2.4	-0.01	-0.1	3.15	4.0	5.13	7.8	-1.18	-0.7	3.59	0.4
1.41	4.15	2.4	-0.01	0.0	3.14	4.0	5.15	7.8	-1.37	-0.8	4.07	0.4
1.42	4.14	2.3	-0.03	-0.1	3.09	3.9	5.18	7.9	-1.64	-0.9	4.54	0.4
1.43	4.17	2.4	0.02	0.1	2.98	3.8	5.20	7.9	-1.95	-1.0	4.85	0.5
1.44	4.17	2.4	-0.02	-0.1	2.89	3.7	5.22	7.9	-2.18	-1.0	4.95	0.5
1.45	4.14	2.3	0.02	0.0	2.83	3.6	5.23	7.9	-2.33	-1.1	5.00	0.5
1.46	4.14	2.3	-0.01	0.0	2.79	3.6	5.24	8.0	-2.43	-1.1	5.04	0.5
1.47	4.12	2.3	0.00	-0.0	2.77	3.5	5.25	8.0	-2.48	-1.1	5.04	0.5
1.48	4.10	2.3	0.01	0.0	2.75	3.5	5.25	8.0	-2.51	-1.1	5.05	0.5
1.49	4.09	2.3	-0.01	-0.0	2.74	3.5	5.25	8.0	-2.52	-1.1	5.04	0.5
1.50	4.07	2.3	0.01	0.0	2.74	3.5	5.25	8.0	-2.52	-1.1	5.03	0.5
1.51	4.06	2.3	-0.01	-0.0	2.74	3.5	5.25	8.0	-2.52	-1.1	5.01	0.5
1.52	4.04	2.3	0.01	0.0	2.74	3.5	5.25	8.0	-2.50	-1.1	4.99	0.5
1.53	4.02	2.3	-0.00	0.0	2.74	3.5	5.25	8.0	-2.49	-1.1	4.97	0.5
1.54	4.01	2.3	0.00	-0.0	2.74	3.5	5.25	8.0	-2.48	-1.1	4.94	0.5
1.55	4.01	2.3	0.01	0.0	2.72	3.5	5.24	8.0	-2.44	-1.1	4.85	0.5
1.56	4.00	2.3	0.00	0.0	2.71	3.5	5.24	8.0	-2.37	-1.1	4.68	0.5
1.57	3.98	2.3	0.01	0.0	2.72	3.5	5.23	7.9	-2.25	-1.0	4.50	0.4
1.58	3.97	2.2	0.00	0.0	2.73	3.5	5.22	7.9	-2.13	-1.0	4.30	0.4
1.59	3.93	2.2	0.01	0.0	2.76	3.5	5.21	7.9	-1.98	-1.0	4.08	0.4

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

*************** TIME HISTORY OF FLOW AND VELOCITY ***************

Q(CFS), VEL(FPS)

TIME	CONDUIT 9012		CONDUIT 9018		CONDUIT 9036		CONDUIT 9029		CONDUIT
0.20	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.21	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.22	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.23	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.24	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.25	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.26	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.27	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.28	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.29	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.30	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.31	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.32	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.33	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.34	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.35	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.36	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.37	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.38	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.39	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.40	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.41	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.42	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.43	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.44	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.45	0.00	0.0	-0.22	0.0	0.00	0.0	0.00	0.0	
0.46	0.00	0.0	-0.28	-0.1	0.00	0.0	0.00	0.0	
0.47	0.00	0.0	-0.31	-0.1	0.00	0.0	0.00	0.0	
0.48	0.00	0.0	-0.30	-0.1	0.00	0.0	0.00	0.0	
0.49	0.00	0.0	-0.25	-0.1	0.00	0.0	0.00	0.0	
0.50	0.00	0.0	-0.24	-0.1	0.00	0.0	0.00	0.0	
0.51	-0.32	-0.1	-0.74	-0.2	0.00	0.0	0.00	0.0	
0.52	-0.09	-0.1	-1.20	-0.3	0.00	0.0	0.00	0.0	
0.53	0.24	0.1	-1.74	-0.5	0.00	0.0	0.00	0.0	
0.54	0.54	0.2	-2.22	-0.7	0.00	0.0	0.00	0.0	
0.55	0.84	0.3	-2.71	-0.9	0.00	0.0	0.00	0.0	
0.56	1.12	0.4	-3.14	-1.0	0.00	0.0	0.00	0.0	
0.57	1.41	0.5	-3.61	-1.2	0.00	0.0	0.00	0.0	
0.58	1.67	0.6	-4.04	-1.3	0.00	0.0	0.00	0.0	
0.59	1.88	0.7	-4.42	-1.4	0.00	0.0	0.00	0.0	
1. 0	2.06	0.8	-4.80	-1.5	0.00	0.0	-0.25	-0.1	
1. 1	2.20	0.8	-5.15	-1.6	0.00	0.0	-0.18	-0.1	
1. 2	2.33	0.8	-5.43	-1.7	0.00	0.0	-0.15	-0.1	
1. 3	2.42	0.9	-5.72	-1.8	0.00	0.0	-0.16	-0.1	
1. 4	2.49	0.9	-5.97	-1.9	0.00	0.2	-0.31	-0.1	
1. 5	2.54	0.9	-6.21	-2.0	0.29	2.0	-0.63	-0.2	
1. 6	2.59	0.9	-6.44	-2.1	0.72	2.4	-1.00	-0.4	
1. 7	2.55	0.9	-7.03	-2.2	1.10	2.7	-1.22	-0.5	

1, 8	2.62	0.9	-7.40	-2.4	1.23	2.3	-1.27	-0.5
1, 9	2.68	0.9	-7.73	-2.5	1.30	2.2	-1.33	-0.5
1,10	2.73	1.0	-7.91	-2.5	1.36	2.2	-1.39	-0.5
1,11	2.73	1.0	-7.98	-2.6	1.42	2.2	-1.45	-0.5
1,12	2.72	1.0	-8.05	-2.6	1.48	2.1	-1.51	-0.6
1,13	2.71	0.9	-8.12	-2.6	1.54	2.1	-1.57	-0.6
1,14	2.72	0.9	-8.14	-2.6	1.60	2.1	-1.63	-0.6
1,15	2.71	0.9	-8.17	-2.6	1.66	2.1	-1.69	-0.6
1,16	2.71	0.9	-8.19	-2.6	1.72	2.1	-1.75	-0.7
1,17	2.69	0.9	-8.29	-2.7	1.78	2.0	-1.81	-0.7
1,18	2.69	0.9	-8.34	-2.7	1.84	2.0	-1.87	-0.7
1,19	2.69	0.9	-8.36	-2.7	1.89	1.9	-1.89	-0.7
1,20	2.69	0.9	-8.37	-2.7	1.84	1.7	-1.79	-0.7
1,21	2.68	0.9	-8.38	-2.7	1.75	1.7	-1.71	-0.6
1,22	2.69	0.9	-8.37	-2.7	1.66	1.6	-1.62	-0.6
1,23	2.70	0.9	-8.33	-2.7	1.58	1.7	-1.53	-0.6
1,24	2.70	0.9	-8.29	-2.7	1.49	1.8	-1.44	-0.5
1,25	2.72	0.9	-8.21	-2.6	1.40	1.9	-1.34	-0.5
1,26	2.74	0.9	-8.10	-2.6	1.27	2.0	-1.19	-0.5
1,27	2.74	1.0	-8.04	-2.6	1.13	2.0	-1.05	-0.4
1,28	2.79	1.0	-7.83	-2.5	0.99	2.0	-0.91	-0.4
1,29	2.80	1.0	-7.67	-2.5	0.86	2.0	-0.77	-0.3
1,30	2.82	1.0	-7.52	-2.4	0.72	1.9	-0.63	-0.2
1,31	2.93	1.0	-6.92	-2.3	0.48	1.8	-0.16	-0.1
1,32	3.02	1.1	-6.27	-2.1	0.14	1.1	0.21	0.1
1,33	3.01	1.1	-5.36	-1.8	0.02	0.5	0.26	0.1
1,34	2.91	1.0	-4.35	-1.5	0.01	0.3	0.24	0.1
1,35	2.76	1.0	-3.42	-1.2	0.00	0.2	0.05	0.0
1,36	2.56	1.0	-2.61	-0.9	0.00	0.2	0.02	0.0
1,37	2.27	0.9	-2.71	-0.9	0.00	0.1	0.01	0.0
1,38	2.09	0.8	-3.03	-1.0	0.00	0.1	0.00	0.0
1,39	2.02	0.8	-3.35	-1.1	0.00	0.1	0.00	0.0
1,40	2.01	0.7	-3.80	-1.2	0.00	0.1	0.00	0.0
1,41	2.05	0.8	-4.26	-1.4	0.00	0.1	0.00	0.0
1,42	2.13	0.8	-4.72	-1.5	0.00	0.0	-0.07	-0.0
1,43	2.25	0.8	-4.92	-1.6	0.00	0.0	-0.04	-0.0
1,44	2.36	0.9	-4.96	-1.6	0.00	0.0	0.00	-0.0
1,45	2.42	0.9	-5.02	-1.6	0.00	0.0	0.02	0.0
1,46	2.46	0.9	-5.04	-1.6	0.00	0.0	0.02	0.0
1,47	2.48	0.9	-5.05	-1.6	0.00	0.0	0.02	0.0
1,48	2.50	0.9	-5.05	-1.6	0.00	0.0	0.02	0.0
1,49	2.51	0.9	-5.03	-1.6	0.00	0.0	0.03	0.0
1,50	2.51	0.9	-5.03	-1.6	0.00	0.0	0.01	0.0
1,51	2.51	0.9	-5.00	-1.6	0.00	0.0	0.01	0.0
1,52	2.51	0.9	-4.98	-1.6	0.00	0.0	0.00	0.0
1,53	2.51	0.9	-4.96	-1.6	0.00	0.0	0.00	0.0
1,54	2.50	0.9	-4.93	-1.6	0.00	0.0	0.00	0.0
1,55	2.51	0.9	-4.80	-1.6	0.00	0.0	0.00	0.0
1,56	2.51	0.9	-4.61	-1.5	0.00	0.0	0.00	0.0
1,57	2.49	0.9	-4.42	-1.4	0.00	0.0	0.00	0.0
1,58	2.47	0.9	-4.22	-1.4	0.00	0.0	0.00	0.0
1,59	2.43	0.9	-4.00	-1.3	0.00	0.0	0.00	0.0

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

''''''''''''''''''' SUMMARY STATISTICS FOR CONDUITS ''''''''''''''''''

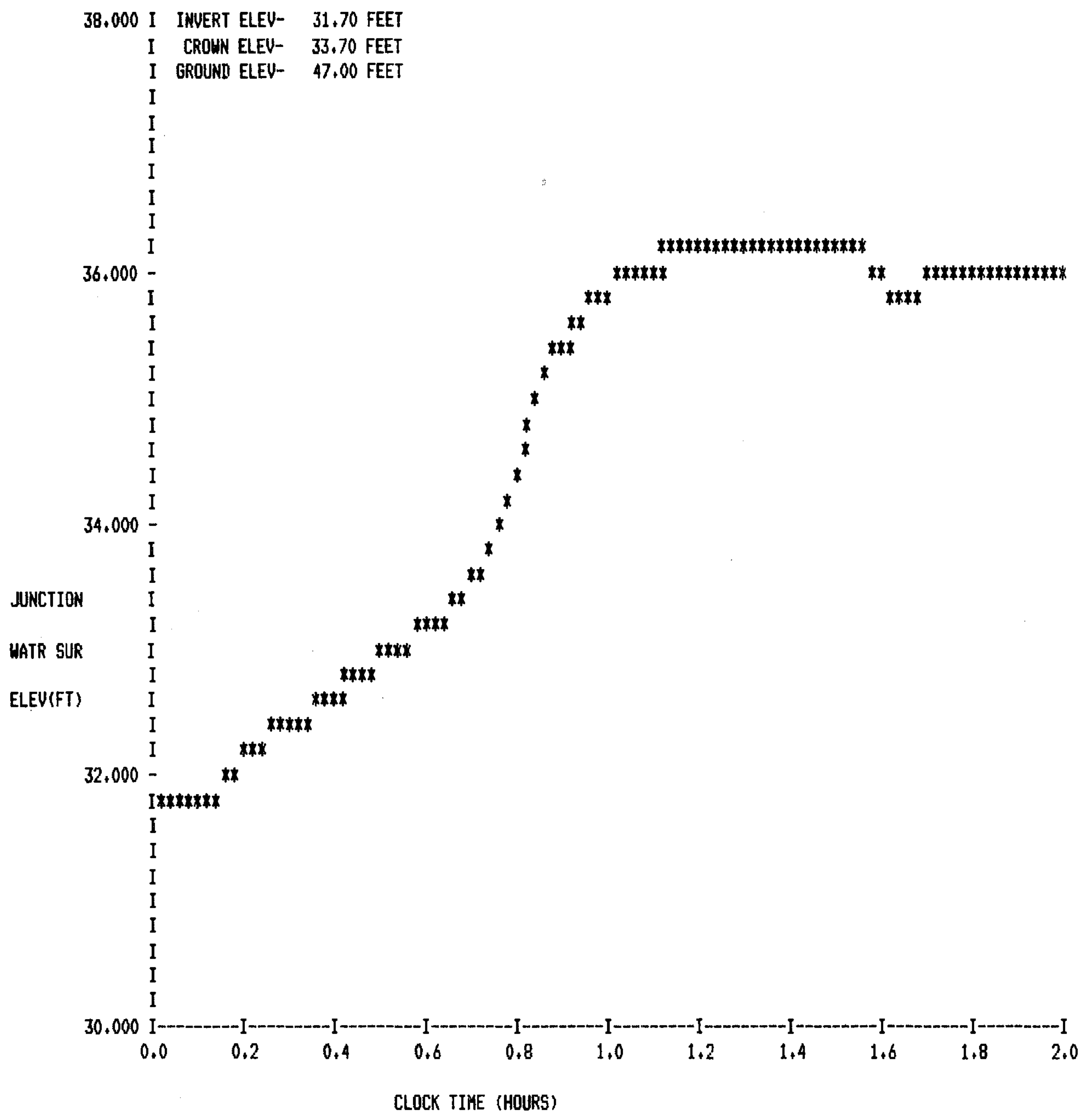
CONDUIT NUMBER	DESIGN FLOW (CFS)	DESIGN VELOCITY (FPS)	CONDUIT VERTICAL DEPTH (IN)	MAXIMUM COMPUTED FLOW (CFS)	TIME OF OCCURENCE HR.	TIME OF OCCURENCE MIN.	MAXIMUM COMPUTED VELOCITY (FPS)	TIME OF OCCURENCE HR.	TIME OF OCCURENCE MIN.	RATIO OF MAX. TO DESIGN FLOW	MAXIMUM DEPTH ABOVE INVERT AT CONDUIT ENDS UPSTREAM (FT)	DOWNSTREAM (FT)
1	979.6	2.7	120.0	349.5	2	0	3.4	2	0	0.4	4.27	4.10
2	979.6	2.7	120.0	348.7	2	0	3.6	2	0	0.4	4.10	3.88
3	979.6	2.7	120.0	286.4	2	0	3.2	2	0	0.3	3.88	3.71
4	979.6	2.7	120.0	285.7	2	0	3.4	2	0	0.3	3.71	3.50
5	979.6	2.7	120.0	285.1	2	0	3.8	2	0	0.3	3.50	3.19
6	979.6	2.7	120.0	284.5	2	0	5.2	2	0	0.3	3.19	1.96
7	63.3	4.2	36.0	4.3	1	10	0.6	0	1	0.1	3.00	3.88
8	632.8	42.2	36.0	6.0	1	24	0.9	1	24	0.0	0.24	3.00
9	228.3	14.3	24.0	5.6	1	24	5.1	1	24	0.0	0.75	0.24
10	174.4	10.9	24.0	5.6	1	24	3.3	1	23	0.0	0.55	0.75
11	93.2	5.8	24.0	0.0	0	0	0.0	0	0	0.0	0.55	1.27
35	64.8	7.8	19.2	24.3	1	21	5.4	1	21	0.4	1.00	1.15
34	30.2	7.5	12.0	5.4	1	23	2.5	0	51	0.2	0.41	1.00
13	32.9	8.2	12.0	5.4	1	23	4.8	1	23	0.2	0.39	0.41
12	1.8	2.3	12.0	5.4	1	23	8.2	1	23	3.0	4.54	0.39
14	2.7	3.4	12.0	4.9	0	51	6.2	0	52	1.8	4.55	4.54
17	11.8	6.7	18.0	4.6	1	16	2.9	0	1	0.4	3.70	4.55
16	15.8	8.9	18.0	4.6	1	16	7.5	0	1	0.3	0.89	3.70
15	18.2	10.3	18.0	4.6	1	13	21.8	0	0	0.3	0.51	0.89
19	2.4	6.2	8.4	1.8	1	22	4.7	1	22	0.8	2.82	4.55
21	2.1	5.4	8.4	1.8	1	21	4.7	1	21	0.9	2.10	2.82
24	2.7	6.9	8.4	1.8	1	21	6.6	1	7	0.7	0.42	2.10
26	1.7	4.4	8.4	1.8	1	21	21.5	1	4	1.1	1.10	0.42
18	64.8	7.8	19.2	18.9	1	20	5.1	1	20	0.3	0.89	1.00
20	58.0	7.0	19.2	18.9	1	20	5.2	1	20	0.3	0.99	0.89
22	41.0	4.9	19.2	18.9	1	20	4.1	1	20	0.5	1.21	0.99
23	82.0	9.9	19.2	18.9	1	20	4.7	1	19	0.2	0.79	1.21
25	29.0	3.5	19.2	18.9	1	19	3.5	1	20	0.7	1.59	0.79
27	45.8	5.5	19.2	18.9	1	19	3.0	1	19	0.4	1.05	1.59
30	11.8	6.7	18.0	18.9	1	19	11.4	1	19	1.6	3.90	1.05
29	18.2	10.3	18.0	4.9	1	7	3.3	1	7	0.3	0.53	3.90
28	12.9	7.3	18.0	4.9	1	7	6.2	1	6	0.4	0.84	0.53
31	71.0	8.5	19.2	15.9	1	19	2.3	1	19	0.2	0.78	3.90
32	58.0	7.0	19.2	15.9	1	18	4.9	1	19	0.3	0.95	0.78
33	64.8	7.8	19.2	15.9	1	18	12.9	0	0	0.2	0.81	0.95
1014	29.1	2.3	6.0	8.3	1	22	0.8	1	22	0.3	0.37	1.27
1019	19.1	2.6	6.0	0.0	0	0	0.0	0	0	0.0	0.00	0.37
1021	93.5	4.7	12.0	0.0	0	0	0.0	0	0	0.0	0.00	0.00

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

''''''''''''''''''' SUMMARY STATISTICS FOR CONDUITS '''''''''''''''''''

CONDUIT NUMBER	DESIGN FLOW (CFS)	DESIGN VELOCITY (FPS)	CONDUIT VERTICAL DEPTH (IN)	MAXIMUM COMPUTED FLOW (CFS)	TIME OF OCCURENCE HR.	TIME OF OCCURENCE MIN.	MAXIMUM COMPUTED VELOCITY (FPS)	TIME OF OCCURENCE HR.	TIME OF OCCURENCE MIN.	RATIO OF MAX. TO DESIGN FLOW	MAXIMUM DEPTH ABOVE INVERT AT CONDUIT ENDS UPSTREAM (FT)	MAXIMUM DEPTH ABOVE INVERT AT CONDUIT ENDS DOWNSTREAM (FT)
1024	35.2	3.1	6.0	0.0	0	0	0.0	0	0	0.0	0.00	0.00
1026	25.6	1.3	12.0	0.0	0	0	0.0	0	0	0.0	-0.11	0.00
1036	122.3	3.6	18.0	1.9	1	19	1.9	1	4	0.0	0.36	-0.11
9012	26.7	8.5	24.0	3.0	1	33	1.1	1	33	0.1	1.27	4.54
9018	31.0	9.9	24.0	0.0	0	0	0.0	0	0	0.0	1.87	4.55
9029	25.5	8.1	24.0	0.3	1	33	0.1	1	34	0.0	0.86	3.90
9036	22.3	7.1	24.0	1.9	1	19	3.2	1	6	0.1	0.39	1.10

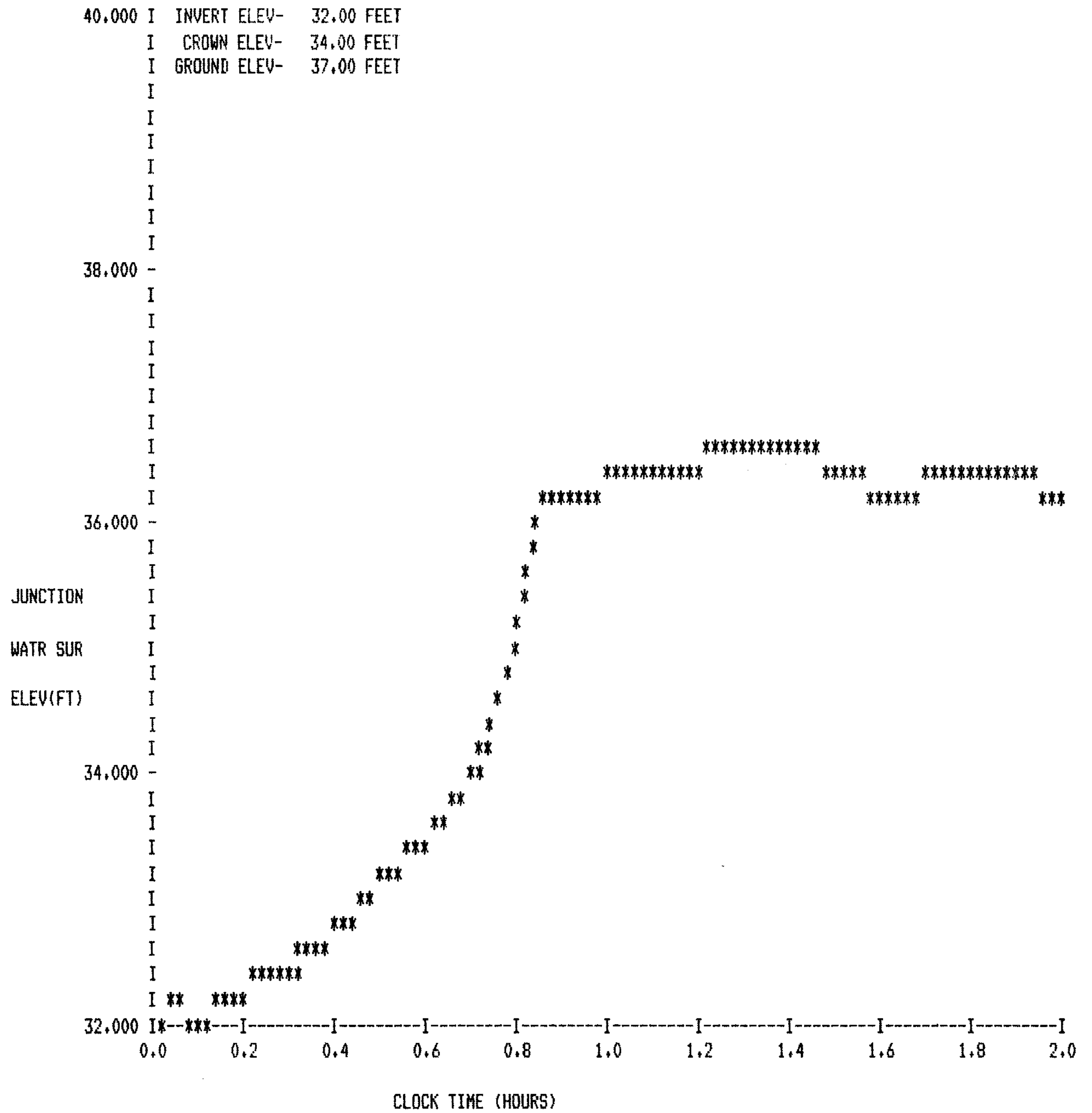
ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



JUNCTION NUMBER 12

FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

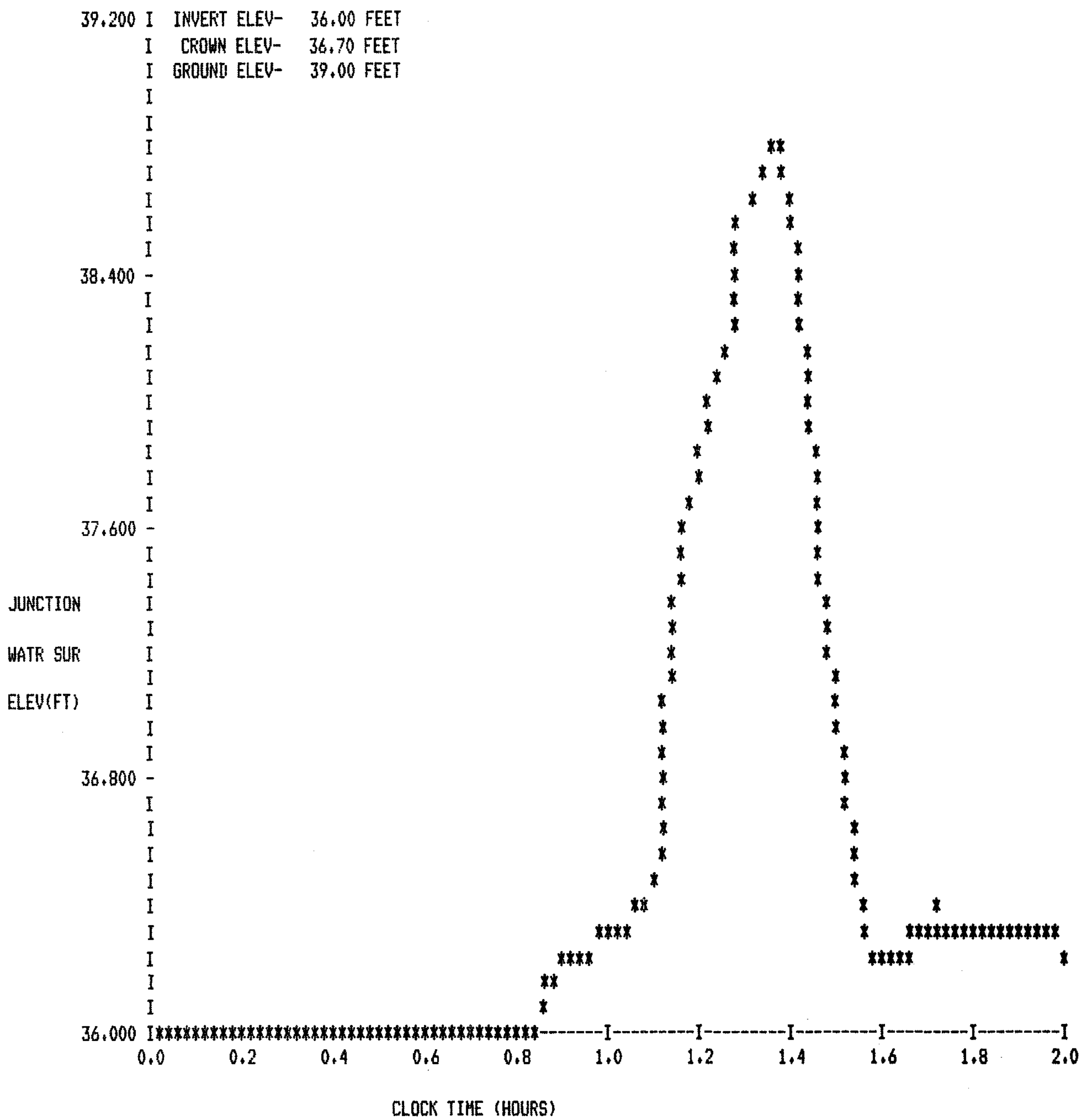
ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



JUNCTION NUMBER 18

FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

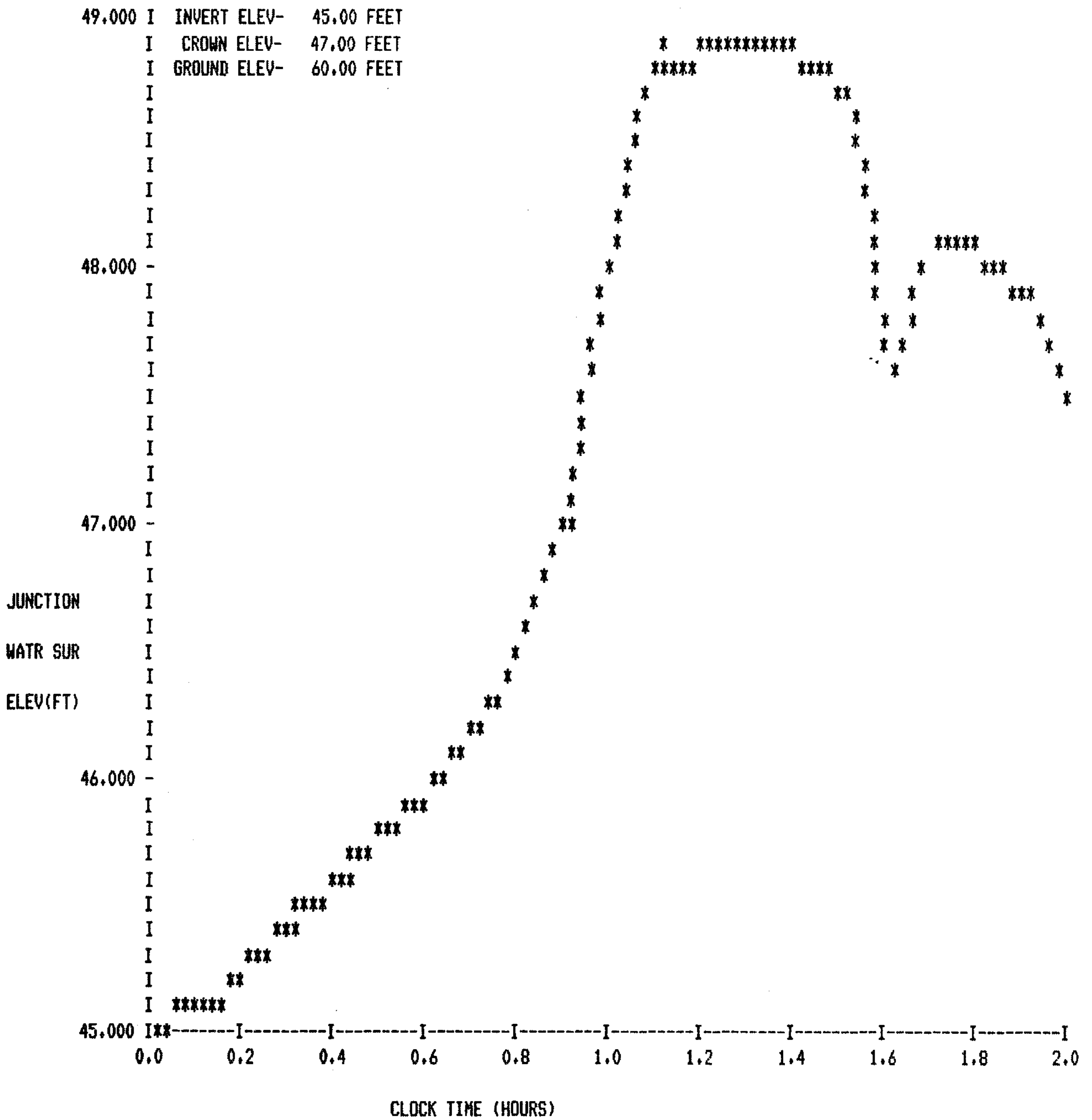
ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



JUNCTION NUMBER 20

FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

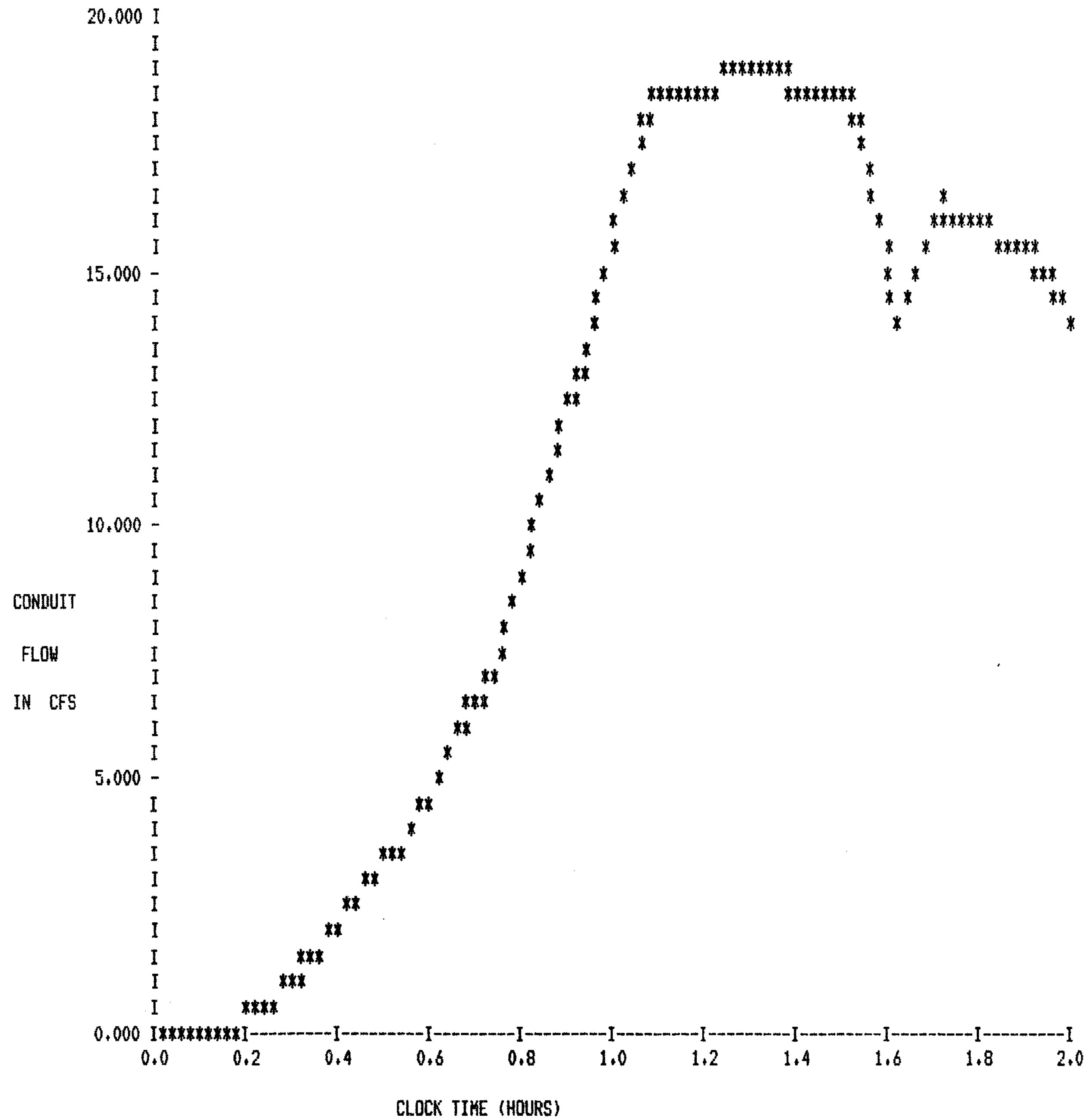
ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



JUNCTION NUMBER 29

FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

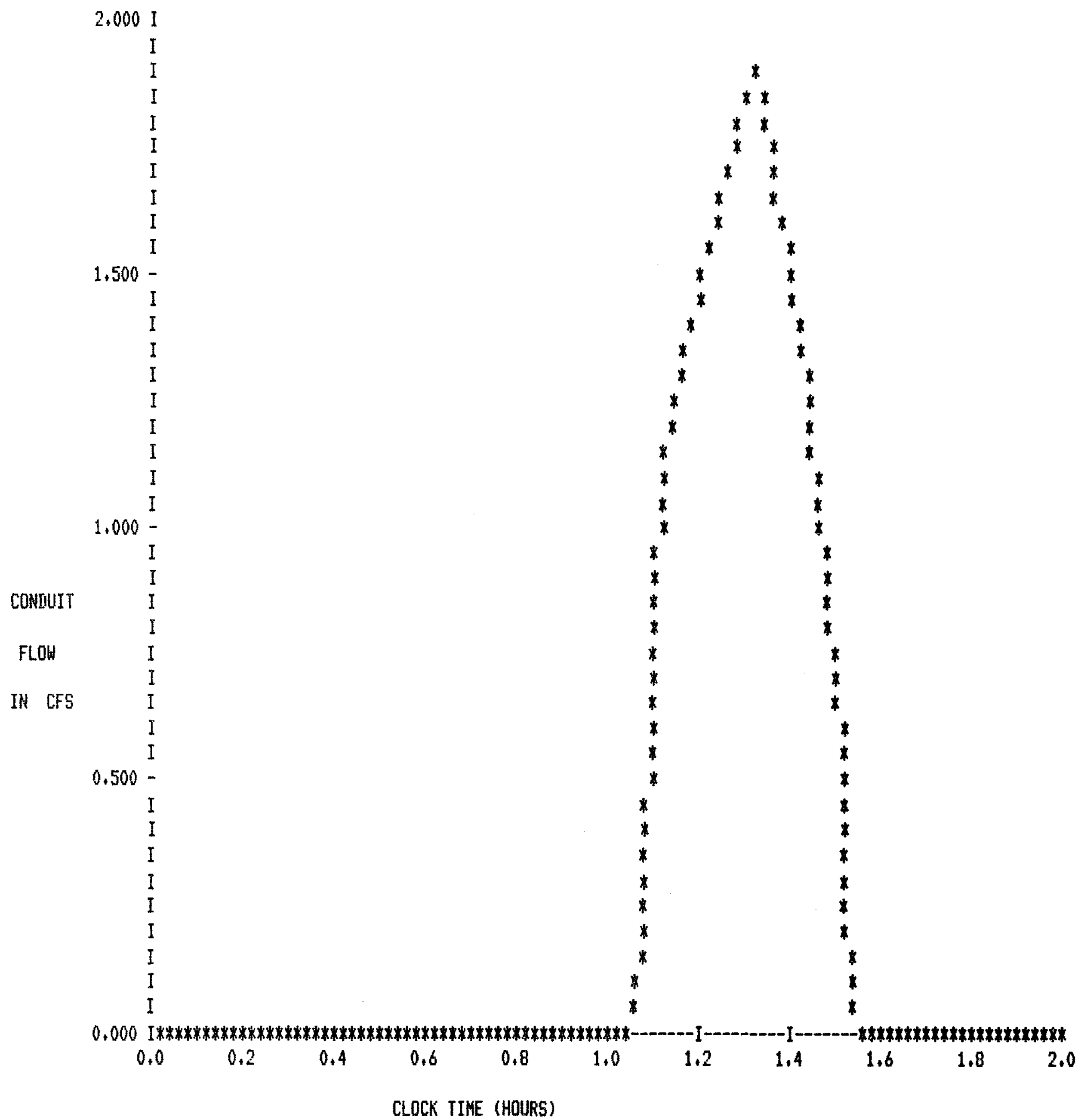
ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



CONDUIT NUMBER 30

FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

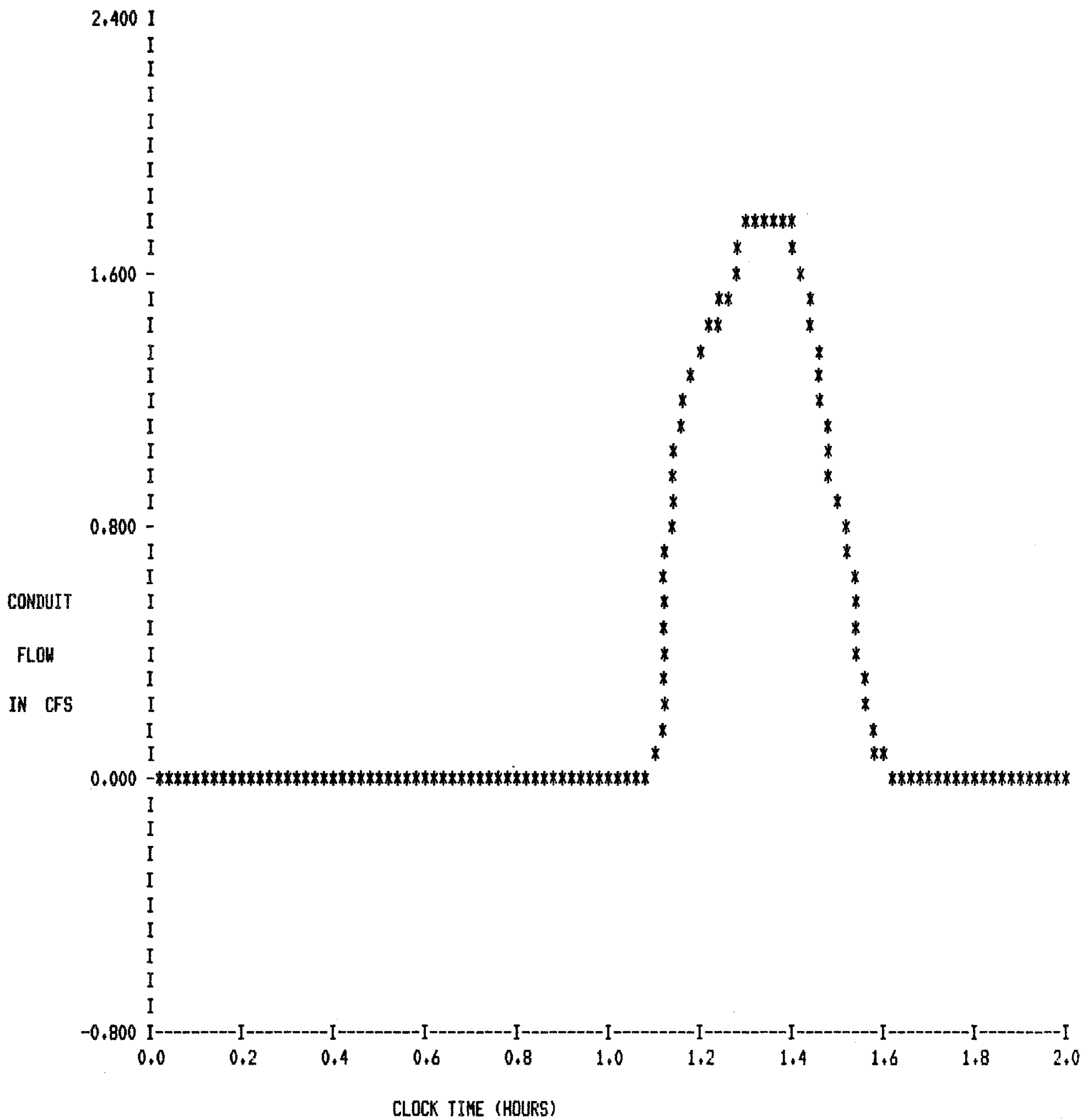
ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



CONDUIT NUMBER 1036

FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

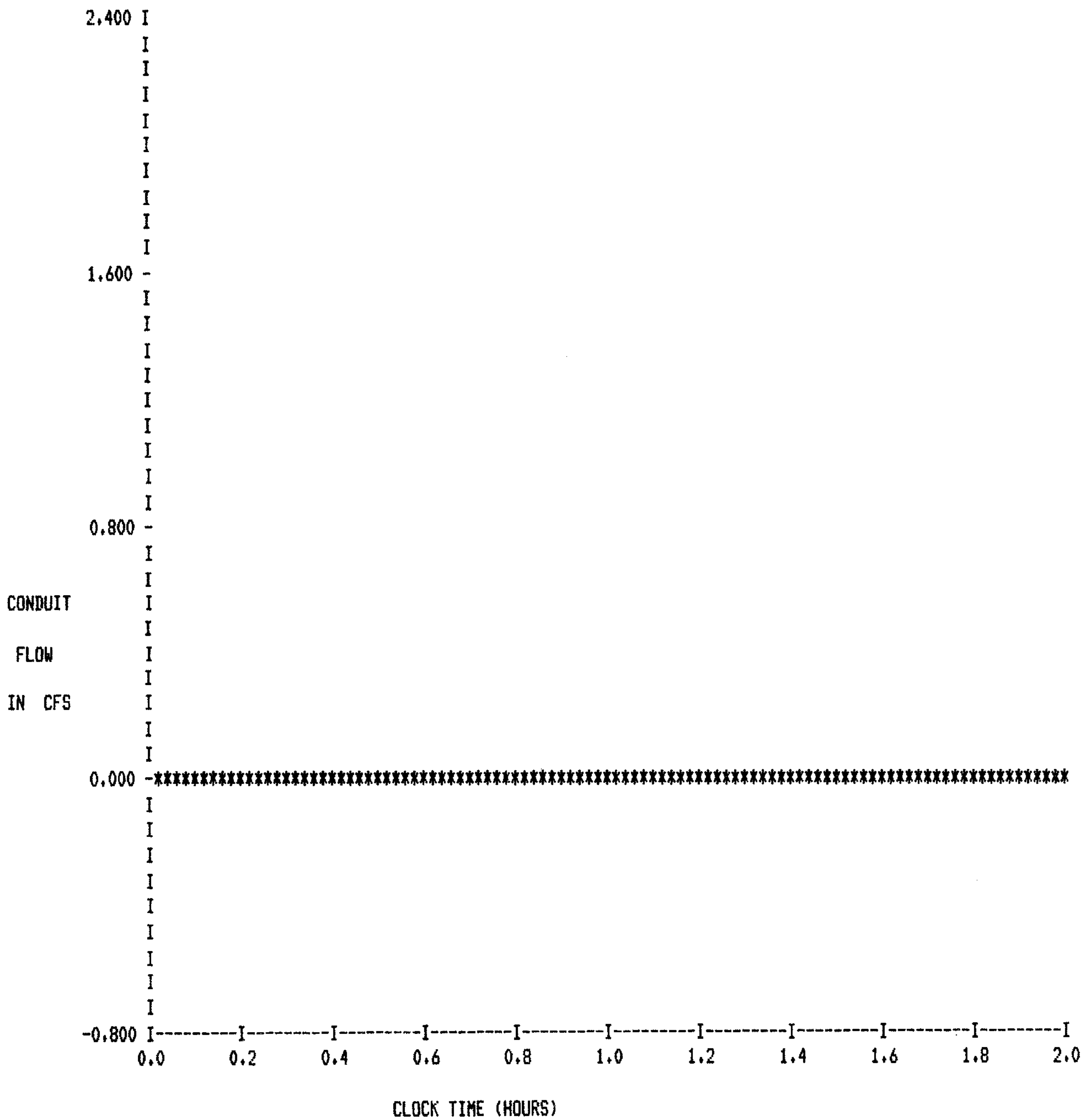


CONDUIT NUMBER 19

RANGE AND SCALE ARE ZERO ON PLOT ATTEMPT

FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

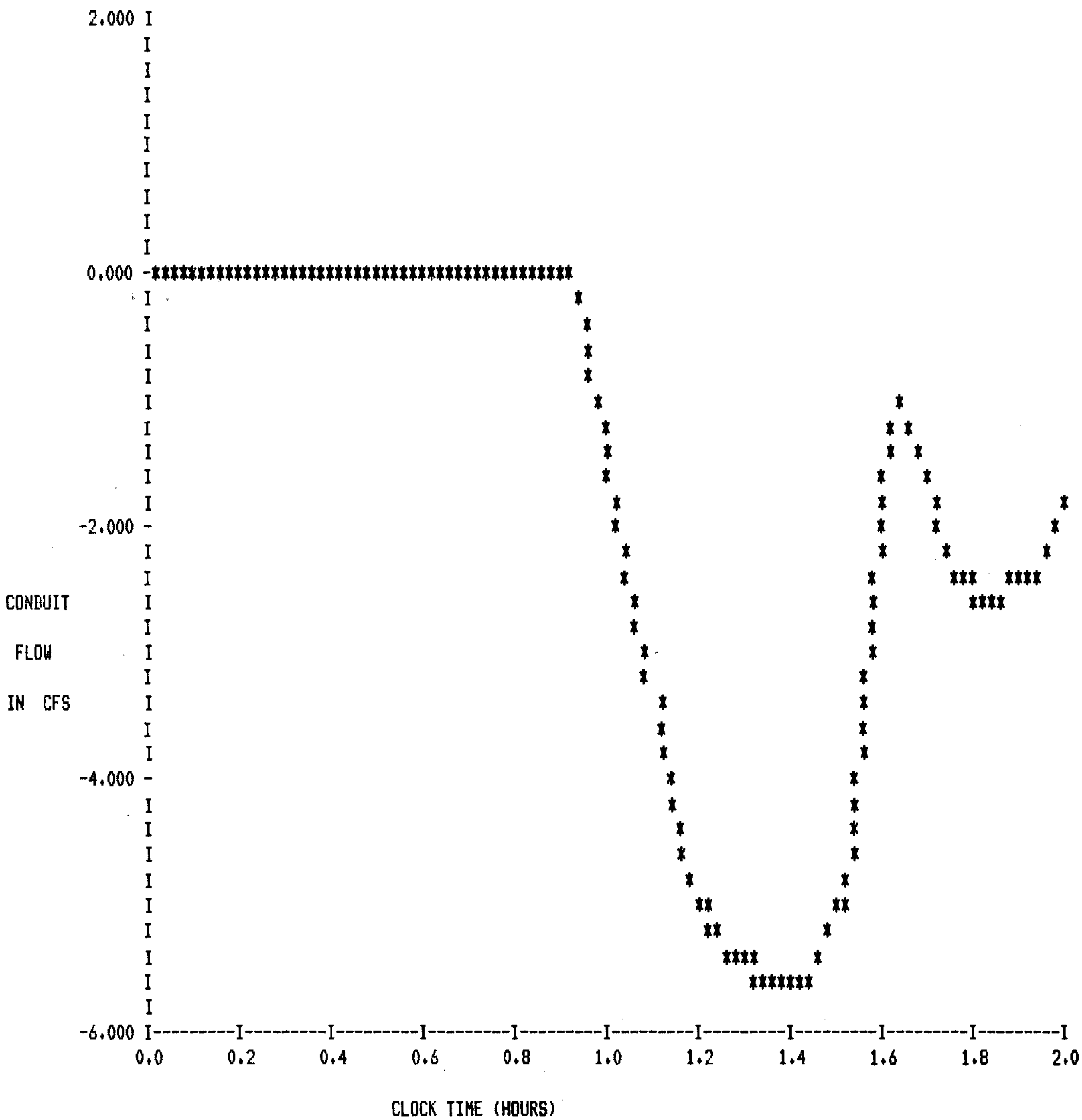
ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



CONDUIT NUMBER 1019

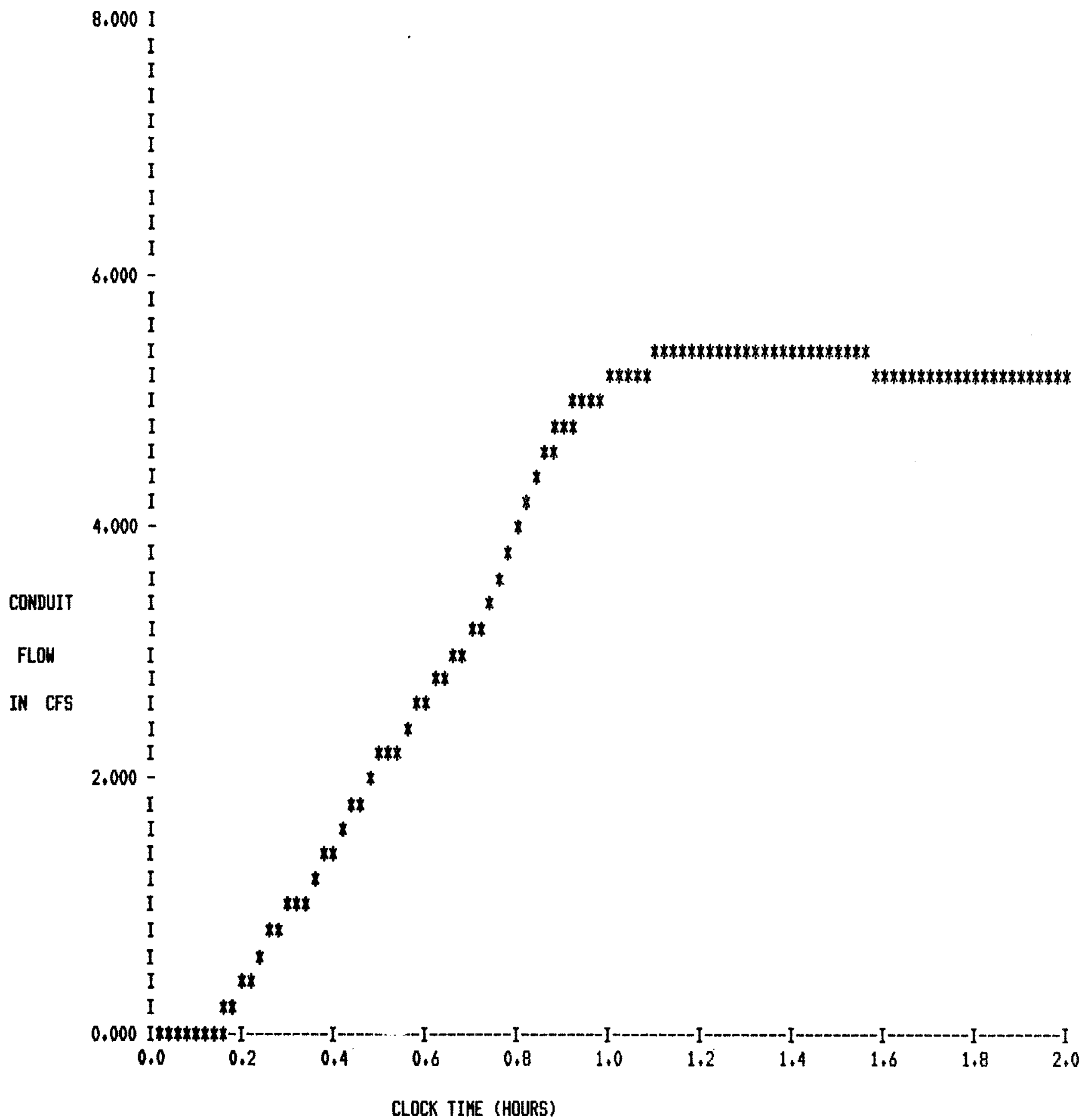
FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



CONDUIT NUMBER 11

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



CONDUIT NUMBER 12

Discussion of Results - Case 1

The model was run for two hours using ten second time steps. This time step did not quite meet the stability requirement, as shown by the printed warnings, but analysis of the results shows that stability is not a problem. At the end of the two hour run there is a continuity error of only 0.25 percent. The listed outflows do show that flooding occurs at Junction 8, however, This indicates that Conduit 7 as specified is not large enough to handle the flow coming from Junction 8. The user should either redefine Conduit 7 to handle the flow or devise some other way to account for the flooding which takes place.

Further study of the results shows that Junctions 12, 18, 17, 20, 22, and 29 on or near Line G are surcharged during this storm. The surcharge quantity is great enough to cause flow up out of Manholes 9018 and 9029, but not enough to cause flow in the above ground section of Line G between Junctions 1018 and 1036. An interesting phenomenon exists in the flow pattern at the junction of Lines A, F, and G. Here water is forced up Manhole 9018, flows back down 9012, then joins the flow from Pipe 14 and exits to the outfall through Pipe 12. The printed results shown in Exhibit 4-2 very closely matched those obtained with an earlier version of the program.

Discussion of Results - Case 2

Case 2 of the Bellview-Redmond Road example differs from Case 1 in the following two ways. First, Pipe 30, which passes under the highway, was decreased in diameter from 1.5 to 1.0 feet. Thus both the width and depth of this conduit is changed in the input data set shown in Exhibit 4-1. Second, a broad crested weir was placed at Junction 1018 to simulate flow over the highway from the flooding of this junction. The weir characteristics used in this simulation are:

Type of weir - transverse (KWEIR = 1);
Height of weir crest above invert (YCREST) - 1.8 ft.;
Height to top of weir above invert (YTOP) - 2.1 ft.;
Weir length (WLEN) - 80 ft.; and
Coefficient of discharge for weir (COEF) - 2.7.

These changes were made in Card Group 11. Except for these two revisions, the input data set remained the same for Case 1.

The sections of the output which appreciably differ from Case 1 are shown in Exhibit 4-3. This again shows good results, both internally, demonstrated by a continuity error of only .22 percent, and in comparison with the previous run made with the Analysis Module's predecessor. The major difference between Cases 1 and 2 is the changes in flow pattern caused by constraining the size of Pipe 30. This causes more water to be diverted to Line G, leading to greater surcharges below ground and significant flow in the ditch above ground. A small amount of flooding occurs at Junction 20 and over the weir at Junction 1018. It is apparent, however, that severe flooding still occurs at Junction 8.

The preceding example shows how the Analysis Module serves as a useful tool in diagnosing problems in complex areas of the highway drainage system. With this model, the engineer can easily simulate several possible remedies to problems in a proposed or existing system in order to effectively choose the best available alternative.

EXHIBIT 4-3

Bellview-Redmond Road
Example Problem:
Case 2 Results

```
FEDERAL HIGHWAY ADMINISTRATION          **** URBAN HIGHWAY DRAINAGE PROGRAM ****       WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION            ****                                ****       CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C.                        ****          ANALYSIS MODULE       ****       ANNANDALE, VIRGINIA
            ANALYSIS MODULE EXAMPLE PROBLEM
          BELLVIEW REDMOND ROAD DRAINAGE SYSTEM


INTEGRATION CYCLES  720

LENGTH OF INTEGRATION STEP IS   10. SECONDS

PRINTING STARTS IN CYCLE  121 AND PRINTS AT INTERVALS OF    6 CYCLES

INITIAL TIME  0.00 HOURS

PRINTED OUTPUT AT THE FOLLOWING 18 JUNCTIONS

              31      28      30      29    1029    1036      36      22    1025
            1022    1020    1018      17      18    1018    1012      12      11

        AND FOR THE FOLLOWING 16 CONDUITS

              29      31      30    1036    1026    1019      17      19      14
              12      11    1014    9012    9018    9036    9029

WATER SURFACE ELEVATIONS WILL BE PLOTTED FOR THE FOLLOWING     4 JUNCTIONS

              12      18      20      29

FLOW RATE WILL BE PLOTTED FOR THE FOLLOWING    6 CONDUITS

              30    1036      19    1019      11      12
```

FEDERAL HIGHWAY ADMINISTRATION	**** URBAN HIGHWAY DRAINAGE PROGRAM ****	WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION	**** ****	CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C.	**** ANALYSIS MODULE ****	ANNANDALE, VIRGINIA

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

	CONDUIT NUMBER	LENGTH (FT)	CLASS	AREA (SQ FT)	MANNING COEF.	MAX WIDTH (FT)	DEPTH (FT)	JUNCTIONS AT ENDS		INVERT HEIGHT ABOVE JUNCTIONS		TRAPEZOID SIDE SLOPE
1	1	100.	6	360.00	0.040	16.00	10.00	1	2			2.00 2.00
2	2	100.	6	360.00	0.040	16.00	10.00	2	3			2.00 2.00
3	3	100.	6	360.00	0.040	16.00	10.00	3	4			2.00 2.00
4	4	100.	6	360.00	0.040	16.00	10.00	4	5			2.00 2.00
5	5	100.	6	360.00	0.040	16.00	10.00	5	6			2.00 2.00
6	6	100.	6	360.00	0.040	16.00	10.00	6	7			2.00 2.00
7	7	100.	6	15.00	0.030	2.00	3.00	8	3			1.00 1.00
8	8	30.	6	15.00	0.030	2.00	3.00	9	8			1.00 1.00
9	9	100.	6	16.00	0.025	0.01	2.00	10	9			4.00 4.00
10	10	100.	6	16.00	0.025	0.01	2.00	11	10			4.00 4.00
11	11	50.	6	16.00	0.025	0.01	2.00	1012	11			4.00 4.00
12	35	100.	6	8.32	0.040	2.00	1.60	14	35			2.00 2.00
13	34	100.	6	4.00	0.030	2.00	1.00	13	14			2.00 2.00
14	13	40.	6	4.00	0.030	2.00	1.00	34	13			2.00 2.00
15	12	60.	1	0.79	0.015	1.00	1.00	12	34			
16	14	40.	1	0.79	0.015	1.00	1.00	18	12			
17	17	60.	1	1.77	0.015	1.50	1.50	17	18			
18	16	100.	1	1.77	0.015	1.50	1.50	16	17			
19	15	100.	1	1.77	0.015	1.50	1.50	15	16			
20	19	100.	1	0.38	0.015	0.70	0.70	20	18			
21	21	100.	1	0.38	0.015	0.70	0.70	22	20			
22	24	100.	1	0.38	0.015	0.70	0.70	25	22			
23	26	50.	1	0.38	0.015	0.70	0.70	36	25			
24	18	60.	6	8.32	0.040	2.00	1.60	19	14			2.00 2.00
25	20	100.	6	8.32	0.040	2.00	1.60	21	19			2.00 2.00
26	22	100.	6	8.32	0.040	2.00	1.60	23	21			2.00 2.00
27	23	100.	6	8.32	0.040	2.00	1.60	24	23			2.00 2.00
28	25	100.	6	8.32	0.040	2.00	1.60	26	24			2.00 2.00
29	27	40.	6	8.32	0.040	2.00	1.60	30	26			2.00 2.00
30	30	60.	1	0.79	0.015	1.00	1.00	29	30			
31	29	100.	1	1.77	0.015	1.50	1.50	28	29			
32	28	100.	1	1.77	0.015	1.50	1.50	27	28			
33	31	100.	6	8.32	0.040	2.00	1.60	31	29			2.00 2.00
34	32	100.	6	8.32	0.040	2.00	1.60	32	31			2.00 2.00
35	33	100.	6	8.32	0.040	2.00	1.60	33	32			2.00 2.00
36	1014	40.	6	12.50	0.040	0.01	0.50	1018	1012	1.50	0.00	60.0040.00
37	1019	100.	6	7.50	0.040	0.01	0.50	1020	1018	0.00	1.50	30.0030.00
38	1021	100.	6	20.00	0.040	0.01	1.00	1022	1020			30.0010.00
39	1024	100.	6	11.25	0.040	0.01	0.50	1025	1022			60.0030.00
40	1026	100.	6	20.00	0.040	0.01	1.00	1036	1025	0.50	0.00	30.0010.00
41	1036	50.	6	33.75	0.040	0.01	1.50	1029	1036	0.50	0.50	20.0010.00
42	9012	100.	1	3.14	0.020	2.00	2.00	1012	12			
43	9018	100.	1	3.14	0.015	2.00	2.00	1018	18			
44	9029	100.	1	3.14	0.020	2.00	2.00	1029	29			
45	9036	100.	1	3.14	0.020	2.00	2.00	1036	36			

**** WARNING **** (C*DELT/LEN) IN CONDUIT 1 IS 1.8 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 2 IS 1.8 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 3 IS 1.8 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 4 IS 1.8 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 5 IS 1.8 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 6 IS 1.8 AT FULL DEPTH.

```
**** WARNING **** (C*DELT/LEN) IN CONDUIT    8 IS  3.3 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   11 IS  1.6 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   13 IS  1.4 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   14 IS  1.4 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   17 IS  1.2 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   18 IS  1.2 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT   27 IS  1.8 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 1014 IS  1.0 AT FULL DEPTH.
**** WARNING **** (C*DELT/LEN) IN CONDUIT 1036 IS  1.4 AT FULL DEPTH.
```

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

	JUNCTION NUMBER	GROUND ELEV.	CROWN ELEV.	INVERT ELEV.	QINST (CFS)	CONNECTING CONDUITS			
1	1	22.15	22.15	12.15	0.00	1			
2	2	22.10	22.10	12.10	0.00	1	2		
3	3	22.05	22.05	12.05	0.00	2	3	7	
4	4	22.00	22.00	12.00	0.00	3	4		
5	5	21.95	21.95	11.95	0.00	4	5		
6	6	21.90	21.90	11.90	0.00	5	6		
7	7	21.85	21.85	11.85	0.00	6			
8	8	15.50	15.50	12.50	0.00	7	8		
9	9	29.00	29.00	26.00	0.00	8	9		
10	10	34.00	34.00	32.00	0.00	9	10		
11	11	37.50	37.50	35.50	0.00	10	11		
12	1012	37.00	37.00	35.00	0.00	11	1014	9012	
13	35	21.61	21.60	20.00	0.00	35			
14	14	26.61	26.60	25.00	0.00	35	34	18	
15	13	30.40	30.40	29.40	0.00	34	13		
16	34	32.50	32.50	31.50	0.00	13	12		
17	12	47.00	33.70	31.70	0.00	12	14	9012	
18	18	37.00	34.00	32.00	0.00	14	17	19	9018
19	17	38.00	34.50	33.00	0.00	17	16		
20	16	41.00	37.50	36.00	0.00	16	15		
21	15	44.00	41.50	40.00	0.00	15			
22	20	39.00	36.70	36.00	0.00	19	21		
23	22	43.00	39.70	39.00	0.00	21	24		
24	25	57.50	44.70	44.00	0.00	24	26		
25	36	58.80	47.00	45.00	0.00	26	9036		
26	19	29.60	29.60	28.00	0.00	18	20		
27	21	33.60	33.60	32.00	0.00	20	22		
28	23	35.60	35.60	34.00	0.00	22	23		
29	24	43.60	43.60	42.00	0.00	23	25		
30	26	44.60	44.60	43.00	0.00	25	27		
31	30	50.00	45.60	44.00	0.00	27	30		
32	29	60.00	47.00	45.00	0.00	30	29	31	9029
33	28	52.50	50.50	49.00	0.00	29	28		
34	27	55.00	52.50	51.00	0.00	28			
35	31	52.60	52.60	51.00	0.00	31	32		
36	32	56.60	56.60	55.00	0.00	32	33		
37	33	61.60	61.60	60.00	0.00	33			
38	1025	48.50	48.50	47.50	0.00	1024	1026		
39	1036	49.30	49.30	47.30	0.00	1026	1036	9036	
40	1029	50.00	50.00	48.00	0.00	1036	9029		
41	1018	36.50	36.50	34.50	0.00	1014	1019	9018	
42	1020	40.00	40.00	39.00	0.00	1019	1021		
43	1022	44.00	44.00	43.00	0.00	1021	1024		

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

WEIR DATA

JUNCTION FROM	JUNCTION TO	LINK NUMBER	TYPE	CREST HEIGHT(FT)	WEIR TOP(FT)	WEIR LENGTH(FT)	DISCHARGE COEFF.
1018	0	90046	1	1.80	2.10	80.00	2.70

FREE OUTFALL DATA

FREE OUTFLOW AT JUNCTIONS 7 35

INTERNAL CONNECTIVITY INFORMATION

CONDUIT	JUNCTION	JUNCTION
90046	1018	0
90047	7	0
90048	35	0

SUMMARY OF INITIAL HEADS, FLOWS AND VELOCITIES

INITIAL HEADS, FLOWS AND VELOCITIES ARE ZERO

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

****** SYSTEM INFLOWS (CARDS) AT 0.10 HOURS FOR 6 JUNCTIONS

1/ 0.00	9/ 0.01	15/ 0.10	18/ 0.02	27/ 0.02	33/ 0.10

****** SYSTEM INFLOWS (CARDS) AT 0.20 HOURS (JUNCTION / INFLOW,CFS)

1/ 5.00	9/ 0.04	15/ 0.50	18/ 0.07	27/ 0.06	33/ 0.50

CYCLE 6 TIME 0 HRS - 1.00 MIN

JUNCTIONS / DEPTHS

1/ 0.37	2/ 0.18	3/ 0.01	4/ 0.00	5/ 0.00	6/ 0.00	7/ 0.00	8/ 0.13
9/ 0.00	10/ 0.00	11/ 0.00	1012/ 0.00	35/ 0.00	14/ 0.00	13/ 0.00	
34/ 0.00	12/ 0.00	18/ 0.05	17/ 0.15	16/ 0.13	15/ 0.00	20/ 0.00	
22/ 0.00	25/ 0.00	36/ 0.00	19/ 0.00	21/ 0.00	23/ 0.00	24/ 0.00	
26/ 0.00	30/ 0.00	29/ 0.01	28/ 0.00	27/ 0.00	31/ 0.01	32/ 0.13	
33/ 0.00	1025/ 0.00	1036/ 0.00	1029/ 0.00	1018/ 0.00	1020/ 0.00	1022/ 0.00	

CONDUITS / FLOWS

1/ 3.58	2/ 0.55	3/ 0.00	4/ 0.00	5/ 0.00	6/ 0.00	7/ 0.08	8/ 0.00
9/ 0.00	10/ 0.00	11/ 0.00	35/ 0.00	34/ 0.00	13/ 0.00	12/ 0.00	
14/ 0.00	17/ 0.15	16/ 0.30	15/ 0.00	19/ 0.00	21/ 0.00	24/ 0.00	
26/ 0.00	18/ 0.00	20/ 0.00	22/ -0.00	23/ 0.00	25/ 0.00	27/ 0.00	
30/ 0.00	29/ 0.00	28/ 0.00	31/ 0.01	32/ 0.11	33/ 0.00	1014/ 0.00	
1019/ 0.00	1021/ 0.00	1024/ 0.00	1026/ 0.00	1036/ 0.00	9012/ 0.00	9018/ 0.00	
9029/ 0.00	9036/ 0.00	90046/ 0.00	90047/ 0.00	90048/ 0.00			

- CONTINUITY BALANCE AT END OF RUN - - - - - - - - - - - - - - - - - -

TOTAL SYSTEM INFLOW VOLUME = 1284473. CU FT

JUNCTION OUTFLOWS AND
STREET FLOODING

JUNCTION	OUTFLOW, FT3
7	992515.
8	144505.
35	66137.
20	1873.
1018	23313.

TOTAL 1228343. CU FT

VOLUME LEFT IN SYSTEM = 58927. CU FT

ERROR IN CONTINUITY, PERCENT = -0.22

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

********************* TIME HISTORY OF H. G. L. *********************

(VALUES IN FEET)

TIME	JUNCTION 31		JUNCTION 28		JUNCTION 30		JUNCTION 29		JUNCTION 1029		JUNCTION 1036	
	GRND 52.60		GRND 52.50		GRND 50.00		GRND 60.00		GRND 50.00		GRND 49.30	
HR . MIN	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH
0.20	51.20	0.20	49.09	0.09	44.25	0.25	45.57	0.57	48.00	0.00	47.30	0.00
0.21	51.22	0.22	49.10	0.10	44.27	0.27	45.62	0.62	48.00	0.00	47.30	0.00
0.22	51.23	0.23	49.10	0.10	44.28	0.28	45.66	0.66	48.00	0.00	47.30	0.00
0.23	51.25	0.25	49.10	0.10	44.30	0.30	45.71	0.71	48.00	0.00	47.30	0.00
0.24	51.26	0.26	49.11	0.11	44.32	0.32	45.75	0.75	48.00	0.00	47.30	0.00
0.25	51.27	0.27	49.11	0.11	44.33	0.33	45.80	0.80	48.00	0.00	47.30	0.00
0.26	51.28	0.28	49.11	0.11	44.35	0.35	45.85	0.85	48.00	0.00	47.30	0.00
0.27	51.30	0.30	49.12	0.12	44.37	0.37	45.90	0.90	48.00	0.00	47.30	0.00
0.28	51.31	0.31	49.12	0.12	44.38	0.38	45.95	0.95	48.00	0.00	47.30	0.00
0.29	51.32	0.32	49.13	0.13	44.39	0.39	46.02	1.02	48.00	0.00	47.30	0.00
0.30	51.33	0.33	49.13	0.13	44.41	0.41	46.08	1.08	48.00	0.00	47.30	0.00
0.31	51.35	0.35	49.13	0.13	44.43	0.43	46.15	1.15	48.00	0.00	47.30	0.00
0.32	51.36	0.36	49.14	0.14	44.44	0.44	46.21	1.21	48.00	0.00	47.30	0.00
0.33	51.37	0.37	49.14	0.14	44.45	0.45	46.29	1.29	48.00	0.00	47.30	0.00
0.34	51.38	0.38	49.14	0.14	44.47	0.47	46.36	1.36	48.00	0.00	47.30	0.00
0.35	51.39	0.39	49.15	0.15	44.48	0.48	46.45	1.45	48.00	0.00	47.30	0.00
0.36	51.41	0.41	49.15	0.15	44.48	0.48	46.56	1.56	48.00	0.00	47.30	0.00
0.37	51.42	0.42	49.16	0.16	44.49	0.49	46.69	1.69	48.00	0.00	47.30	0.00
0.38	51.43	0.43	49.16	0.16	44.50	0.50	46.84	1.84	48.00	0.00	47.30	0.00
0.39	51.44	0.44	49.17	0.17	44.51	0.51	46.99	1.99	48.00	0.00	47.30	0.00
0.40	51.45	0.45	49.17	0.17	44.53	0.53	47.34	2.00	48.00	0.00	47.30	0.00
0.41	51.47	0.47	49.18	0.18	44.56	0.56	47.81	2.00	48.00	0.00	47.30	0.00
0.42	51.48	0.48	49.19	0.19	44.58	0.58	48.13	2.00	48.14	0.14	47.30	0.00
0.43	51.49	0.49	49.21	0.21	44.60	0.60	48.41	2.00	48.42	0.42	47.30	0.00
0.44	51.50	0.50	49.24	0.24	44.61	0.61	48.70	2.00	48.68	0.68	47.36	0.06
0.45	51.51	0.51	49.26	0.26	44.62	0.62	48.83	2.00	48.80	0.80	47.63	0.33
0.46	51.52	0.52	49.28	0.28	44.62	0.62	48.90	2.00	48.85	0.85	47.68	0.38
0.47	51.53	0.53	49.30	0.30	44.63	0.63	48.95	2.00	48.89	0.89	47.73	0.43
0.48	51.55	0.55	49.32	0.32	44.63	0.63	49.00	2.00	48.91	0.91	47.77	0.47
0.49	51.56	0.56	49.33	0.33	44.63	0.63	49.04	2.00	48.94	0.94	47.81	0.51
0.50	51.57	0.57	49.35	0.35	44.63	0.63	49.09	2.00	48.96	0.96	47.86	0.56
0.51	51.58	0.58	49.36	0.36	44.64	0.64	49.14	2.00	48.98	0.98	48.09	0.79
0.52	51.59	0.59	49.37	0.37	44.64	0.64	49.18	2.00	48.98	0.98	48.22	0.92
0.53	51.60	0.60	49.39	0.39	44.64	0.64	49.20	2.00	48.96	0.96	48.30	1.00
0.54	51.61	0.61	49.40	0.40	44.64	0.64	49.25	2.00	48.97	0.97	48.33	1.03
0.55	51.62	0.62	49.41	0.41	44.64	0.64	49.31	2.00	48.98	0.98	48.37	1.07
0.56	51.64	0.64	49.43	0.43	44.65	0.65	49.37	2.00	49.00	1.00	48.40	1.10
0.57	51.65	0.65	49.53	0.53	44.65	0.65	49.45	2.00	49.01	1.01	48.42	1.12
0.58	51.66	0.66	49.59	0.59	44.65	0.65	49.50	2.00	49.03	1.03	48.45	1.15
0.59	51.68	0.68	49.67	0.67	44.66	0.66	49.57	2.00	49.04	1.04	48.47	1.17
1. 0	51.69	0.69	49.76	0.76	44.66	0.66	49.64	2.00	49.05	1.05	48.49	1.19
1. 1	51.70	0.70	49.85	0.85	44.66	0.66	49.72	2.00	49.06	1.06	48.51	1.21
1. 2	51.71	0.71	49.95	0.95	44.67	0.67	49.79	2.00	49.07	1.07	48.53	1.23
1. 3	51.72	0.72	50.04	1.04	44.67	0.67	49.86	2.00	49.08	1.08	48.55	1.25
1. 4	51.73	0.73	50.14	1.14	44.67	0.67	49.94	2.00	49.09	1.09	48.56	1.26

1. 5	51.74	0.74	50.24	1.24	44.68	0.68	50.02	2.00	49.10	1.10	48.58	1.28
1. 6	51.75	0.75	50.35	1.35	44.68	0.68	50.10	2.00	49.11	1.11	48.59	1.29
1. 7	51.75	0.75	50.43	1.43	44.68	0.68	50.16	2.00	49.12	1.12	48.61	1.31
1. 8	51.75	0.75	50.45	1.45	44.68	0.68	50.18	2.00	49.12	1.12	48.62	1.32
1. 9	51.76	0.76	50.47	1.47	44.69	0.69	50.19	2.00	49.13	1.13	48.62	1.32
1.10	51.76	0.76	50.48	1.48	44.69	0.69	50.20	2.00	49.13	1.13	48.62	1.32
1.11	51.76	0.76	50.50	1.50	44.69	0.69	50.21	2.00	49.13	1.13	48.63	1.33
1.12	51.76	0.76	50.51	1.50	44.69	0.69	50.23	2.00	49.13	1.13	48.63	1.33
1.13	51.77	0.77	50.53	1.50	44.69	0.69	50.24	2.00	49.13	1.13	48.63	1.33
1.14	51.77	0.77	50.54	1.50	44.69	0.69	50.25	2.00	49.13	1.13	48.63	1.33
1.15	51.77	0.77	50.55	1.50	44.69	0.69	50.27	2.00	49.13	1.13	48.63	1.33
1.16	51.77	0.77	50.56	1.50	44.69	0.69	50.28	2.00	49.14	1.14	48.64	1.34
1.17	51.77	0.77	50.58	1.50	44.69	0.69	50.29	2.00	49.14	1.14	48.64	1.34
1.18	51.78	0.78	50.59	1.50	44.69	0.69	50.30	2.00	49.14	1.14	48.64	1.34
1.19	51.77	0.77	50.60	1.50	44.69	0.69	50.31	2.00	49.14	1.14	48.64	1.34
1.20	51.77	0.77	50.58	1.50	44.69	0.69	50.29	2.00	49.14	1.14	48.64	1.34
1.21	51.77	0.77	50.56	1.50	44.69	0.69	50.27	2.00	49.14	1.14	48.64	1.34
1.22	51.77	0.77	50.54	1.50	44.69	0.69	50.26	2.00	49.13	1.13	48.64	1.34
1.23	51.76	0.76	50.53	1.50	44.69	0.69	50.24	2.00	49.13	1.13	48.63	1.33
1.24	51.76	0.76	50.51	1.50	44.69	0.69	50.22	2.00	49.13	1.13	48.63	1.33
1.25	51.76	0.76	50.49	1.49	44.69	0.69	50.20	2.00	49.13	1.13	48.63	1.33
1.26	51.75	0.75	50.45	1.45	44.69	0.69	50.17	2.00	49.13	1.13	48.62	1.32
1.27	51.75	0.75	50.41	1.41	44.68	0.68	50.14	2.00	49.12	1.12	48.62	1.32
1.28	51.74	0.74	50.38	1.38	44.68	0.68	50.11	2.00	49.12	1.12	48.62	1.32
1.29	51.74	0.74	50.35	1.35	44.68	0.68	50.08	2.00	49.11	1.11	48.61	1.31
1.30	51.73	0.73	50.31	1.31	44.68	0.68	50.05	2.00	49.11	1.11	48.60	1.30
1.31	51.73	0.73	50.16	1.16	44.68	0.68	49.97	2.00	49.10	1.10	48.60	1.30
1.32	51.72	0.72	49.98	0.98	44.67	0.67	49.86	2.00	49.09	1.09	48.58	1.28
1.33	51.72	0.72	49.81	0.81	44.67	0.67	49.74	2.00	49.07	1.07	48.56	1.26
1.34	51.71	0.71	49.65	0.65	44.66	0.66	49.63	2.00	49.06	1.06	48.54	1.24
1.35	51.71	0.71	49.52	0.52	44.66	0.66	49.52	2.00	49.04	1.04	48.51	1.21
1.36	51.70	0.70	49.40	0.40	44.65	0.65	49.41	2.00	49.02	1.02	48.48	1.18
1.37	51.70	0.70	49.44	0.44	44.65	0.65	49.41	2.00	49.01	1.01	48.45	1.15
1.38	51.70	0.70	49.50	0.50	44.65	0.65	49.46	2.00	49.02	1.02	48.45	1.15
1.39	51.69	0.69	49.56	0.56	44.65	0.65	49.50	2.00	49.03	1.03	48.46	1.16
1.40	51.69	0.69	49.63	0.63	44.66	0.66	49.55	2.00	49.04	1.04	48.47	1.17
1.41	51.69	0.69	49.70	0.70	44.66	0.66	49.60	2.00	49.05	1.05	48.49	1.19
1.42	51.69	0.69	49.78	0.78	44.66	0.66	49.65	2.00	49.05	1.05	48.50	1.20
1.43	51.69	0.69	49.80	0.80	44.66	0.66	49.67	2.00	49.06	1.06	48.51	1.21
1.44	51.68	0.68	49.79	0.79	44.66	0.66	49.66	2.00	49.06	1.06	48.52	1.22
1.45	51.68	0.68	49.78	0.78	44.66	0.66	49.65	2.00	49.06	1.06	48.52	1.22
1.46	51.68	0.68	49.76	0.76	44.66	0.66	49.64	2.00	49.05	1.05	48.51	1.21
1.47	51.68	0.68	49.75	0.75	44.66	0.66	49.63	2.00	49.05	1.05	48.51	1.21
1.48	51.67	0.67	49.74	0.74	44.66	0.66	49.62	2.00	49.05	1.05	48.51	1.21
1.49	51.67	0.67	49.73	0.73	44.66	0.66	49.61	2.00	49.05	1.05	48.51	1.21
1.50	51.67	0.67	49.71	0.71	44.66	0.66	49.60	2.00	49.05	1.05	48.50	1.20
1.51	51.67	0.67	49.70	0.70	44.66	0.66	49.58	2.00	49.04	1.04	48.50	1.20
1.52	51.66	0.66	49.69	0.69	44.66	0.66	49.57	2.00	49.04	1.04	48.50	1.20
1.53	51.66	0.66	49.68	0.68	44.66	0.66	49.56	2.00	49.04	1.04	48.49	1.19
1.54	51.66	0.66	49.67	0.67	44.66	0.66	49.55	2.00	49.04	1.04	48.49	1.19
1.55	51.66	0.66	49.63	0.63	44.66	0.66	49.53	2.00	49.04	1.04	48.49	1.19
1.56	51.65	0.65	49.58	0.58	44.65	0.65	49.50	2.00	49.03	1.03	48.48	1.18
1.57	51.65	0.65	49.54	0.54	44.65	0.65	49.47	2.00	49.02	1.02	48.47	1.17
1.58	51.65	0.65	49.50	0.50	44.65	0.65	49.44	2.00	49.02	1.02	48.46	1.16
1.59	51.65	0.65	49.45	0.45	44.65	0.65	49.40	2.00	49.01	1.01	48.45	1.15

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

********************* T I M E H I S T O R Y O F H. G. L. *********************
(VALUES IN FEET)

	JUNCTION 36		JUNCTION 22		JUNCTION 1025		JUNCTION 1022		JUNCTION 1020		JUNCTION 1018	
TIME	GRND 58.80		GRND 43.00		GRND 48.50		GRND 44.00		GRND 40.00		GRND 36.50	
HR . MIN	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH
0.20	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.21	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.22	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.23	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.24	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.25	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.26	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.27	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.28	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.29	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.30	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.31	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.32	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.33	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.34	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.35	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.36	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.37	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.38	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.39	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.40	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.41	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.42	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.43	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.44	45.00	0.00	39.00	0.00	47.50	0.00	43.00	0.00	39.00	0.00	34.50	0.00
0.45	45.31	0.31	39.01	0.01	47.50	0.00	43.00	0.00	39.00	0.00	34.52	0.02
0.46	45.58	0.58	39.52	0.52	47.50	0.00	43.00	0.00	39.00	0.00	34.76	0.26
0.47	45.88	0.88	39.48	0.48	47.50	0.00	43.00	0.00	39.00	0.00	35.31	0.81
0.48	46.27	1.27	39.53	0.53	47.50	0.00	43.00	0.00	39.00	0.00	35.84	1.34
0.49	46.81	1.81	41.49	0.70	47.50	0.00	43.00	0.00	39.00	0.00	36.16	1.66
0.50	48.00	2.00	42.40	0.70	47.50	0.00	43.00	0.00	39.00	0.00	36.20	1.70
0.51	48.07	2.00	42.60	0.70	47.54	0.04	43.01	0.01	39.00	0.00	36.22	1.72
0.52	48.20	2.00	42.66	0.70	47.61	0.11	43.03	0.03	39.00	0.00	36.24	1.74
0.53	48.28	2.00	42.70	0.70	47.67	0.17	43.11	0.11	39.00	0.00	36.25	1.75
0.54	48.31	2.00	42.72	0.70	47.69	0.19	43.22	0.22	39.04	0.04	36.26	1.76
0.55	48.35	2.00	42.73	0.70	47.70	0.20	43.29	0.29	39.11	0.11	36.27	1.77
0.56	48.38	2.00	42.75	0.70	47.71	0.21	43.33	0.33	39.19	0.19	36.29	1.79
0.57	48.40	2.00	42.76	0.70	47.72	0.22	43.34	0.34	39.24	0.24	36.32	1.82
0.58	48.43	2.00	42.77	0.70	47.73	0.23	43.35	0.35	39.27	0.27	36.34	1.84
0.59	48.45	2.00	42.78	0.70	47.74	0.24	43.36	0.36	39.28	0.28	36.35	1.85
1. 0	48.47	2.00	42.79	0.70	47.75	0.25	43.37	0.37	39.30	0.30	36.36	1.86
1. 1	48.49	2.00	42.79	0.70	47.76	0.26	43.38	0.38	39.31	0.31	36.37	1.87
1. 2	48.51	2.00	42.80	0.70	47.76	0.26	43.39	0.39	39.32	0.32	36.38	1.88
1. 3	48.53	2.00	42.81	0.70	47.77	0.27	43.40	0.40	39.33	0.33	36.38	1.88
1. 4	48.54	2.00	42.81	0.70	47.78	0.28	43.42	0.42	39.34	0.34	36.39	1.89

1, 5	48.56	2.00	42.82	0.70	47.79	0.29	43.43	0.43	39.35	0.35	36.40	1.90
1, 6	48.57	2.00	42.83	0.70	47.79	0.29	43.44	0.44	39.36	0.36	36.40	1.90
1, 7	48.59	2.00	42.83	0.70	47.80	0.30	43.45	0.45	39.36	0.36	36.41	1.91
1, 8	48.60	2.00	42.84	0.70	47.80	0.30	43.45	0.45	39.37	0.37	36.41	1.91
1, 9	48.60	2.00	42.84	0.70	47.81	0.31	43.46	0.46	39.38	0.38	36.41	1.91
1,10	48.60	2.00	42.84	0.70	47.81	0.31	43.46	0.46	39.38	0.38	36.42	1.92
1,11	48.60	2.00	42.84	0.70	47.81	0.31	43.46	0.46	39.38	0.38	36.42	1.92
1,12	48.61	2.00	42.84	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,13	48.61	2.00	42.84	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,14	48.61	2.00	42.84	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,15	48.61	2.00	42.84	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,16	48.61	2.00	42.85	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,17	48.62	2.00	42.85	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,18	48.62	2.00	42.85	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,19	48.62	2.00	42.85	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,20	48.62	2.00	42.85	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,21	48.62	2.00	42.85	0.70	47.81	0.31	43.48	0.48	39.39	0.39	36.42	1.92
1,22	48.61	2.00	42.85	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,23	48.61	2.00	42.85	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,24	48.61	2.00	42.84	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,25	48.61	2.00	42.84	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,26	48.60	2.00	42.84	0.70	47.81	0.31	43.47	0.47	39.39	0.39	36.42	1.92
1,27	48.60	2.00	42.84	0.70	47.81	0.31	43.46	0.46	39.39	0.39	36.42	1.92
1,28	48.59	2.00	42.84	0.70	47.80	0.30	43.46	0.46	39.39	0.39	36.42	1.92
1,29	48.59	2.00	42.84	0.70	47.80	0.30	43.46	0.46	39.38	0.38	36.42	1.92
1,30	48.58	2.00	42.83	0.70	47.80	0.30	43.46	0.46	39.38	0.38	36.42	1.92
1,31	48.58	2.00	42.83	0.70	47.80	0.30	43.45	0.45	39.38	0.38	36.41	1.91
1,32	48.56	2.00	42.83	0.70	47.79	0.29	43.45	0.45	39.38	0.38	36.40	1.90
1,33	48.54	2.00	42.82	0.70	47.79	0.29	43.44	0.44	39.37	0.37	36.40	1.90
1,34	48.52	2.00	42.81	0.70	47.78	0.28	43.43	0.43	39.36	0.36	36.39	1.89
1,35	48.49	2.00	42.80	0.70	47.77	0.27	43.41	0.41	39.35	0.35	36.38	1.88
1,36	48.46	2.00	42.79	0.70	47.76	0.26	43.40	0.40	39.34	0.34	36.36	1.86
1,37	48.43	2.00	42.78	0.70	47.74	0.24	43.38	0.38	39.33	0.33	36.36	1.86
1,38	48.43	2.00	42.77	0.70	47.74	0.24	43.36	0.36	39.31	0.31	36.36	1.86
1,39	48.44	2.00	42.77	0.70	47.74	0.24	43.36	0.36	39.30	0.30	36.36	1.86
1,40	48.45	2.00	42.78	0.70	47.74	0.24	43.36	0.36	39.30	0.30	36.36	1.86
1,41	48.47	2.00	42.78	0.70	47.75	0.25	43.37	0.37	39.30	0.30	36.36	1.86
1,42	48.48	2.00	42.79	0.70	47.75	0.25	43.38	0.38	39.31	0.31	36.37	1.87
1,43	48.49	2.00	42.80	0.70	47.76	0.26	43.39	0.39	39.31	0.31	36.37	1.87
1,44	48.50	2.00	42.80	0.70	47.76	0.26	43.39	0.39	39.32	0.32	36.38	1.88
1,45	48.50	2.00	42.80	0.70	47.76	0.26	43.40	0.40	39.33	0.33	36.38	1.88
1,46	48.49	2.00	42.80	0.70	47.76	0.26	43.40	0.40	39.33	0.33	36.38	1.88
1,47	48.49	2.00	42.80	0.70	47.76	0.26	43.40	0.40	39.33	0.33	36.38	1.88
1,48	48.49	2.00	42.80	0.70	47.76	0.26	43.40	0.40	39.33	0.33	36.38	1.88
1,49	48.49	2.00	42.79	0.70	47.76	0.26	43.39	0.39	39.33	0.33	36.38	1.88
1,50	48.48	2.00	42.79	0.70	47.76	0.26	43.39	0.39	39.33	0.33	36.38	1.88
1,51	48.48	2.00	42.79	0.70	47.76	0.26	43.39	0.39	39.33	0.33	36.38	1.88
1,52	48.48	2.00	42.79	0.70	47.76	0.26	43.39	0.39	39.32	0.32	36.38	1.88
1,53	48.47	2.00	42.79	0.70	47.75	0.25	43.39	0.39	39.32	0.32	36.38	1.88
1,54	48.47	2.00	42.79	0.70	47.75	0.25	43.38	0.38	39.32	0.32	36.38	1.88
1,55	48.47	2.00	42.79	0.70	47.75	0.25	43.38	0.38	39.32	0.32	36.37	1.87
1,56	48.46	2.00	42.79	0.70	47.75	0.25	43.38	0.38	39.32	0.32	36.37	1.87
1,57	48.45	2.00	42.78	0.70	47.75	0.25	43.38	0.38	39.32	0.32	36.37	1.87
1,58	48.44	2.00	42.78	0.70	47.74	0.24	43.37	0.37	39.31	0.31	36.36	1.86
1,59	48.43	2.00	42.77	0.70	47.74	0.24	43.37	0.37	39.31	0.31	36.36	1.86

FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

*********************** TIME HISTORY OF H.G.L. ***********************
(VALUES IN FEET)

TIME	JUNCTION 17 GRND 38.00		JUNCTION 18 GRND 37.00		JUNCTION 1018 GRND 36.50		JUNCTION 1012 GRND 37.00		JUNCTION 12 GRND 47.00		JUNCTION 11 GRND 37.50	
HR . MIN	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH	ELEV	DEPTH
0.20	33.32	0.32	32.53	0.53	34.50	0.00	35.00	0.00	32.50	0.80	35.50	0.00
0.21	33.33	0.33	32.58	0.58	34.50	0.00	35.00	0.00	32.54	0.84	35.50	0.00
0.22	33.34	0.34	32.62	0.62	34.50	0.00	35.00	0.00	32.57	0.87	35.50	0.00
0.23	33.35	0.35	32.67	0.67	34.50	0.00	35.00	0.00	32.61	0.91	35.50	0.00
0.24	33.36	0.36	32.72	0.72	34.50	0.00	35.00	0.00	32.65	0.95	35.50	0.00
0.25	33.37	0.37	32.77	0.77	34.50	0.00	35.00	0.00	32.69	0.99	35.50	0.00
0.26	33.38	0.38	32.84	0.84	34.50	0.00	35.00	0.00	32.74	1.04	35.50	0.00
0.27	33.39	0.39	32.90	0.90	34.50	0.00	35.00	0.00	32.78	1.08	35.50	0.00
0.28	33.40	0.40	32.98	0.98	34.50	0.00	35.00	0.00	32.82	1.12	35.50	0.00
0.29	33.41	0.41	33.05	1.05	34.50	0.00	35.00	0.00	32.87	1.17	35.50	0.00
0.30	33.42	0.42	33.11	1.11	34.50	0.00	35.00	0.00	32.92	1.22	35.50	0.00
0.31	33.43	0.43	33.18	1.18	34.50	0.00	35.00	0.00	32.96	1.26	35.50	0.00
0.32	33.43	0.43	33.24	1.24	34.50	0.00	35.00	0.00	33.00	1.30	35.50	0.00
0.33	33.44	0.44	33.30	1.30	34.50	0.00	35.00	0.00	33.05	1.35	35.50	0.00
0.34	33.45	0.45	33.37	1.37	34.50	0.00	35.00	0.00	33.09	1.39	35.50	0.00
0.35	33.46	0.46	33.43	1.43	34.50	0.00	35.00	0.00	33.14	1.44	35.50	0.00
0.36	33.47	0.47	33.50	1.50	34.50	0.00	35.00	0.00	33.18	1.48	35.50	0.00
0.37	33.51	0.51	33.55	1.55	34.50	0.00	35.00	0.00	33.22	1.52	35.50	0.00
0.38	33.58	0.58	33.60	1.60	34.50	0.00	35.00	0.00	33.26	1.56	35.50	0.00
0.39	33.66	0.66	33.67	1.67	34.50	0.00	35.00	0.00	33.30	1.60	35.50	0.00
0.40	33.75	0.75	33.75	1.75	34.50	0.00	35.00	0.00	33.36	1.66	35.50	0.00
0.41	33.85	0.85	33.84	1.84	34.50	0.00	35.00	0.00	33.44	1.74	35.50	0.00
0.42	33.98	0.98	33.96	1.96	34.50	0.00	35.00	0.00	33.53	1.83	35.50	0.00
0.43	34.15	1.15	34.11	2.00	34.50	0.00	35.00	0.00	33.64	1.94	35.50	0.00
0.44	34.36	1.36	34.31	2.00	34.50	0.00	35.00	0.00	33.79	2.00	35.50	0.00
0.45	34.63	1.50	34.55	2.00	34.52	0.02	35.00	0.00	33.98	2.00	35.50	0.00
0.46	34.85	1.50	34.80	2.00	34.76	0.26	35.00	0.00	34.15	2.00	35.50	0.00
0.47	35.36	1.50	35.30	2.00	35.31	0.81	35.00	0.00	34.50	2.00	35.50	0.00
0.48	35.90	1.50	35.84	2.00	35.84	1.34	35.00	0.00	34.89	2.00	35.50	0.00
0.49	36.28	1.50	36.19	2.00	36.16	1.66	35.11	0.11	35.10	2.00	35.50	0.00
0.50	36.33	1.50	36.24	2.00	36.20	1.70	35.34	0.34	35.33	2.00	35.50	0.00
0.51	36.36	1.50	36.27	2.00	36.22	1.72	35.51	0.51	35.50	2.00	35.50	0.00
0.52	36.39	1.50	36.29	2.00	36.24	1.74	35.66	0.66	35.65	2.00	35.64	0.14
0.53	36.41	1.50	36.32	2.00	36.25	1.75	35.79	0.79	35.78	2.00	35.75	0.25
0.54	36.44	1.50	36.34	2.00	36.26	1.76	35.90	0.90	35.88	2.00	35.81	0.31
0.55	36.47	1.50	36.36	2.00	36.27	1.77	35.98	0.98	35.96	2.00	35.86	0.36
0.56	36.50	1.50	36.39	2.00	36.29	1.79	36.06	1.06	36.03	2.00	35.91	0.41
0.57	36.54	1.50	36.43	2.00	36.32	1.82	36.15	1.15	36.12	2.00	35.97	0.47
0.58	36.58	1.50	36.46	2.00	36.34	1.84	36.22	1.22	36.19	2.00	36.02	0.52
0.59	36.61	1.50	36.49	2.00	36.35	1.85	36.25	1.25	36.21	2.00	36.04	0.54
1. 0	36.63	1.50	36.51	2.00	36.36	1.86	36.26	1.26	36.22	2.00	36.04	0.54
1. 1	36.65	1.50	36.52	2.00	36.37	1.87	36.26	1.26	36.23	2.00	36.05	0.55
1. 2	36.66	1.50	36.53	2.00	36.38	1.88	36.27	1.27	36.24	2.00	36.05	0.55
1. 3	36.68	1.50	36.54	2.00	36.38	1.88	36.27	1.27	36.24	2.00	36.05	0.55
1. 4	36.69	1.50	36.56	2.00	36.39	1.89	36.28	1.28	36.25	2.00	36.06	0.56

1. 5	36.70	1.50	36.57	2.00	36.40	1.90	36.29	1.29	36.26	2.00	36.06	0.56
1. 6	36.72	1.50	36.58	2.00	36.40	1.90	36.29	1.29	36.26	2.00	36.06	0.56
1. 7	36.73	1.50	36.59	2.00	36.41	1.91	36.30	1.30	36.27	2.00	36.07	0.57
1. 8	36.73	1.50	36.59	2.00	36.41	1.91	36.30	1.30	36.27	2.00	36.07	0.57
1. 9	36.74	1.50	36.59	2.00	36.41	1.91	36.30	1.30	36.27	2.00	36.07	0.57
1.10	36.75	1.50	36.60	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.07	0.57
1.11	36.75	1.50	36.60	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.07	0.57
1.12	36.76	1.50	36.60	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.13	36.76	1.50	36.60	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.14	36.76	1.50	36.60	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.15	36.76	1.50	36.61	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.16	36.76	1.50	36.61	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.17	36.76	1.50	36.61	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.18	36.76	1.50	36.61	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.19	36.76	1.50	36.61	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.20	36.76	1.50	36.61	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.21	36.76	1.50	36.61	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.22	36.75	1.50	36.60	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.23	36.75	1.50	36.60	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.24	36.75	1.50	36.60	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.25	36.75	1.50	36.60	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.26	36.74	1.50	36.60	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.27	36.74	1.50	36.60	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.28	36.74	1.50	36.60	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.08	0.58
1.29	36.73	1.50	36.59	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.07	0.57
1.30	36.73	1.50	36.59	2.00	36.42	1.92	36.31	1.31	36.28	2.00	36.07	0.57
1.31	36.70	1.50	36.56	2.00	36.41	1.91	36.30	1.30	36.27	2.00	36.07	0.57
1.32	36.67	1.50	36.53	2.00	36.40	1.90	36.29	1.29	36.26	2.00	36.07	0.57
1.33	36.64	1.50	36.50	2.00	36.40	1.90	36.29	1.29	36.25	2.00	36.06	0.56
1.34	36.61	1.50	36.47	2.00	36.39	1.89	36.28	1.28	36.24	2.00	36.06	0.56
1.35	36.58	1.50	36.44	2.00	36.38	1.88	36.27	1.27	36.23	2.00	36.05	0.55
1.36	36.56	1.50	36.42	2.00	36.36	1.86	36.26	1.26	36.22	2.00	36.05	0.55
1.37	36.56	1.50	36.43	2.00	36.36	1.86	36.25	1.25	36.21	2.00	36.04	0.54
1.38	36.58	1.50	36.44	2.00	36.36	1.86	36.25	1.25	36.21	2.00	36.04	0.54
1.39	36.58	1.50	36.45	2.00	36.36	1.86	36.25	1.25	36.21	2.00	36.04	0.54
1.40	36.60	1.50	36.47	2.00	36.36	1.86	36.25	1.25	36.22	2.00	36.04	0.54
1.41	36.61	1.50	36.49	2.00	36.36	1.86	36.25	1.25	36.22	2.00	36.04	0.54
1.42	36.63	1.50	36.51	2.00	36.37	1.87	36.26	1.26	36.23	2.00	36.04	0.54
1.43	36.63	1.50	36.51	2.00	36.37	1.87	36.26	1.26	36.23	2.00	36.05	0.55
1.44	36.63	1.50	36.51	2.00	36.38	1.88	36.27	1.27	36.23	2.00	36.05	0.55
1.45	36.64	1.50	36.51	2.00	36.38	1.88	36.27	1.27	36.24	2.00	36.05	0.55
1.46	36.64	1.50	36.51	2.00	36.38	1.88	36.27	1.27	36.24	2.00	36.05	0.55
1.47	36.64	1.50	36.51	2.00	36.38	1.88	36.27	1.27	36.24	2.00	36.05	0.55
1.48	36.63	1.50	36.51	2.00	36.38	1.88	36.27	1.27	36.24	2.00	36.05	0.55
1.49	36.63	1.50	36.51	2.00	36.38	1.88	36.27	1.27	36.24	2.00	36.05	0.55
1.50	36.63	1.50	36.51	2.00	36.38	1.88	36.27	1.27	36.24	2.00	36.05	0.55
1.51	36.63	1.50	36.51	2.00	36.38	1.88	36.27	1.27	36.24	2.00	36.05	0.55
1.52	36.62	1.50	36.51	2.00	36.38	1.88	36.27	1.27	36.24	2.00	36.05	0.55
1.53	36.62	1.50	36.50	2.00	36.38	1.88	36.27	1.27	36.24	2.00	36.05	0.55
1.54	36.62	1.50	36.50	2.00	36.38	1.88	36.27	1.27	36.23	2.00	36.05	0.55
1.55	36.61	1.50	36.49	2.00	36.37	1.87	36.27	1.27	36.23	2.00	36.05	0.55
1.56	36.60	1.50	36.49	2.00	36.37	1.87	36.26	1.26	36.23	2.00	36.05	0.55
1.57	36.59	1.50	36.48	2.00	36.37	1.87	36.26	1.26	36.23	2.00	36.05	0.55
1.58	36.58	1.50	36.47	2.00	36.36	1.86	36.26	1.26	36.22	2.00	36.04	0.54
1.59	36.57	1.50	36.46	2.00	36.36	1.86	36.25	1.25	36.22	2.00	36.04	0.54

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

SUMMARY STATISTICS FOR JUNCTIONS

JUNCTION NUMBER	GROUND ELEVATION (FT)	UPPERMOST PIPE CROWN ELEVATION (FT)	MAXIMUM COMPUTED DEPTH (FT)	TIME OF OCCURENCE HR.	MIN.	FEET OF SURCHARGE AT MAX. DEPTH	FEET MAX. DEPTH IS BELOW GROUND ELEVATION	LENGTH OF SURCHARGE (MIN)
1	22.15	22.15	4.27	2	0	0.00	5.73	0.0
2	22.10	22.10	4.10	2	0	0.00	5.90	0.0
3	22.05	22.05	3.88	2	0	0.00	6.12	0.0
4	22.00	22.00	3.71	2	0	0.00	6.29	0.0
5	21.95	21.95	3.50	2	0	0.00	6.50	0.0
6	21.90	21.90	3.19	2	0	0.00	6.81	0.0
7	21.85	21.85	1.96	2	0	0.00	8.04	0.0
8	15.50	15.50	3.00	1	10	0.00	0.00	0.0
9	29.00	29.00	0.25	1	21	0.00	2.75	0.0
10	34.00	34.00	0.78	1	23	0.00	1.22	0.0
11	37.50	37.50	0.58	1	22	0.00	1.42	0.0
1012	37.00	37.00	1.31	1	22	0.00	0.69	0.0
35	21.61	21.60	0.85	1	21	0.00	0.76	0.0
14	26.61	26.60	0.75	1	21	0.00	0.86	0.0
13	30.40	30.40	0.41	1	22	0.00	0.59	0.0
34	32.50	32.50	0.39	1	22	0.00	0.61	0.0
12	47.00	33.70	4.58	1	22	2.58	10.72	76.5
18	37.00	34.00	4.61	1	19	2.61	0.39	77.7
17	38.00	34.50	3.76	1	18	2.26	1.24	75.3
16	41.00	37.50	0.96	1	18	0.00	4.04	0.0
15	44.00	41.50	0.51	1	16	0.00	3.49	0.0
20	39.00	36.70	3.00	0	50	2.30	0.00	72.5
22	43.00	39.70	3.85	1	20	3.15	0.15	71.5
25	57.50	44.70	2.70	1	20	2.00	10.80	70.7
36	58.80	47.00	3.62	1	20	1.62	10.18	70.7
19	29.60	29.60	0.58	1	21	0.00	1.02	0.0
21	33.60	33.60	0.65	1	20	0.00	0.95	0.0
23	35.60	35.60	0.80	1	20	0.00	0.80	0.0
24	43.60	43.60	0.51	1	20	0.00	1.09	0.0
26	44.60	44.60	1.09	1	19	0.00	0.51	0.0
30	50.00	45.60	0.69	1	19	0.00	5.31	0.0
29	60.00	47.00	5.31	1	19	3.31	9.69	80.8
28	52.50	50.50	1.60	1	19	0.10	1.90	13.5
27	55.00	52.50	0.64	1	6	0.00	3.36	0.0
31	52.60	52.60	0.78	1	19	0.00	0.82	0.0
32	56.60	56.60	0.95	1	18	0.00	0.65	0.0
33	61.60	61.60	0.81	1	18	0.00	0.79	0.0
1025	48.50	48.50	0.31	1	20	0.00	0.69	0.0

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

SUMMARY STATISTICS FOR JUNCTIONS

JUNCTION NUMBER	GROUND ELEVATION (FT)	UPPERMOST PIPE CROWN ELEVATION (FT)	MAXIMUM COMPUTED DEPTH (FT)	TIME OF OCCURENCE HR.	MIN.	FEET OF SURCHARGE AT MAX. DEPTH	FEET MAX. DEPTH IS BELOW GROUND ELEVATION	LENGTH OF SURCHARGE (MIN)
1036	49.30	49.30	1.34	1	20	0.00	0.66	0.0
1029	50.00	50.00	1.14	1	19	0.00	0.86	0.0
1018	36.50	36.50	1.92	1	21	0.00	0.08	0.0
1020	40.00	40.00	0.39	1	22	0.00	0.61	0.0
1022	44.00	44.00	0.48	1	21	0.00	0.52	0.0

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

*************** TIME HISTORY OF FLOW AND VELOCITY ***************
Q(CFS), VEL(FPS)

TIME	CONDUIT 29		CONDUIT 31		CONDUIT 30		CONDUIT 1036		CONDUIT 1026		CONDUIT 1019	
HR . MIN	FLOW	VEL	FLOW	VEL	FLOW	VEL	FLOW	VEL	FLOW	VEL	FLOW	VEL
0.20	0.14	0.4	1.36	1.2	1.25	4.1	0.00	0.0	0.00	0.0	0.00	0.0
0.21	0.15	0.4	1.54	1.2	1.41	4.2	0.00	0.0	0.00	0.0	0.00	0.0
0.22	0.16	0.4	1.71	1.3	1.59	4.3	0.00	0.0	0.00	0.0	0.00	0.0
0.23	0.17	0.4	1.88	1.3	1.76	4.4	0.00	0.0	0.00	0.0	0.00	0.0
0.24	0.18	0.4	2.05	1.3	1.94	4.5	0.00	0.0	0.00	0.0	0.00	0.0
0.25	0.20	0.4	2.23	1.3	2.12	4.6	0.00	0.0	0.00	0.0	0.00	0.0
0.26	0.21	0.4	2.43	1.3	2.30	4.7	0.00	0.0	0.00	0.0	0.00	0.0
0.27	0.23	0.4	2.63	1.3	2.49	4.8	0.00	0.0	0.00	0.0	0.00	0.0
0.28	0.25	0.4	2.84	1.3	2.68	4.9	0.00	0.0	0.00	0.0	0.00	0.0
0.29	0.27	0.4	3.04	1.3	2.85	5.0	0.00	0.0	0.00	0.0	0.00	0.0
0.30	0.28	0.4	3.24	1.3	3.06	5.2	0.00	0.0	0.00	0.0	0.00	0.0
0.31	0.30	0.4	3.46	1.3	3.28	5.4	0.00	0.0	0.00	0.0	0.00	0.0
0.32	0.32	0.4	3.69	1.2	3.49	5.5	0.00	0.0	0.00	0.0	0.00	0.0
0.33	0.33	0.4	3.93	1.2	3.69	5.7	0.00	0.0	0.00	0.0	0.00	0.0
0.34	0.35	0.4	4.16	1.2	3.89	5.8	0.00	0.0	0.00	0.0	0.00	0.0
0.35	0.37	0.4	4.40	1.2	4.05	6.0	0.00	0.0	0.00	0.0	0.00	0.0
0.36	0.38	0.4	4.64	1.1	4.08	5.9	0.00	0.0	0.00	0.0	0.00	0.0
0.37	0.41	0.4	4.88	1.1	4.23	6.1	0.00	0.0	0.00	0.0	0.00	0.0
0.38	0.45	0.4	5.15	1.1	4.40	6.4	0.00	0.0	0.00	0.0	0.00	0.0
0.39	0.48	0.4	5.42	1.1	4.57	6.6	0.00	0.0	0.00	0.0	0.00	0.0
0.40	0.52	0.4	5.68	1.0	4.94	7.0	0.00	0.0	0.00	0.0	0.00	0.0
0.41	0.56	0.4	5.95	0.9	5.49	7.7	0.00	0.0	0.00	0.0	0.00	0.0
0.42	0.59	0.4	6.22	0.9	5.86	8.2	0.00	0.0	0.00	0.0	0.00	0.0
0.43	0.76	0.5	6.50	1.0	6.16	8.6	0.00	0.0	0.00	0.0	0.00	0.0
0.44	0.96	0.7	6.80	1.0	6.48	9.0	0.19	0.6	0.00	0.0	0.00	0.0
0.45	1.17	0.8	7.11	1.1	6.64	9.2	1.08	1.1	0.00	0.0	0.00	0.0
0.46	1.37	1.0	7.41	1.1	6.71	9.3	1.76	1.3	0.00	0.0	0.00	0.0
0.47	1.57	1.1	7.71	1.2	6.76	9.4	2.24	1.4	0.00	0.0	0.00	0.0
0.48	1.77	1.2	8.01	1.2	6.81	9.5	2.73	1.4	0.00	0.0	0.00	0.0
0.49	1.95	1.4	8.33	1.2	6.86	9.5	3.17	1.5	0.00	0.0	0.00	0.0
0.50	2.12	1.5	8.67	1.3	6.91	9.6	3.63	1.5	0.00	0.1	0.00	0.0
0.51	2.30	1.6	9.00	1.3	6.96	9.7	4.10	1.6	0.35	0.4	0.00	0.0
0.52	2.47	1.7	9.34	1.4	7.01	9.7	5.01	1.7	1.19	0.7	0.00	0.0
0.53	2.64	1.8	9.67	1.4	7.03	9.7	5.13	1.5	2.17	0.8	0.00	0.0
0.54	2.81	2.0	10.01	1.5	7.08	9.8	5.51	1.5	2.66	0.9	0.01	0.0
0.55	2.98	2.1	10.38	1.5	7.14	9.9	5.97	1.4	3.12	1.0	0.32	0.2
0.56	3.10	2.2	10.80	1.6	7.21	9.9	6.48	1.4	3.63	1.0	1.41	0.7
0.57	3.37	2.3	11.22	1.6	7.28	10.0	6.98	1.4	4.15	1.0	2.74	1.1
0.58	3.38	2.3	11.64	1.7	7.34	10.1	7.47	1.4	4.70	1.1	3.66	1.3
0.59	3.54	2.3	12.06	1.8	7.41	10.2	7.92	1.4	5.18	1.1	4.23	1.4
1. 0	3.70	2.4	12.48	1.8	7.48	10.3	8.42	1.4	5.67	1.2	4.68	1.4
1. 1	3.87	2.4	12.88	1.9	7.56	10.4	8.92	1.5	6.18	1.2	5.13	1.5
1. 2	4.05	2.5	13.25	1.9	7.64	10.5	9.40	1.5	6.68	1.2	5.62	1.5
1. 3	4.22	2.5	13.61	2.0	7.71	10.6	9.86	1.5	7.16	1.2	6.13	1.6
1. 4	4.40	2.6	13.98	2.0	7.79	10.7	10.33	1.5	7.63	1.3	6.65	1.7
1. 5	4.58	2.7	14.35	2.1	7.87	10.8	10.79	1.5	8.10	1.3	7.16	1.7
1. 6	4.76	2.7	14.72	2.1	7.95	10.8	11.26	1.5	8.57	1.3	7.65	1.8

1. 7	4.85	2.7	14.95	2.2	8.01	10.9	11.66	1.5	9.03	1.3	8.14	1.8
1. 8	4.87	2.8	15.03	2.2	8.03	11.0	11.82	1.5	9.34	1.3	8.62	1.9
1. 9	4.87	2.8	15.11	2.2	8.04	11.0	11.90	1.5	9.49	1.4	9.04	1.9
1.10	4.87	2.8	15.19	2.2	8.06	11.0	11.97	1.5	9.58	1.4	9.33	1.9
1.11	4.87	2.8	15.28	2.2	8.07	11.0	12.04	1.5	9.65	1.4	9.50	2.0
1.12	4.88	2.8	15.36	2.2	8.08	11.0	12.11	1.5	9.72	1.4	9.60	2.0
1.13	4.88	2.8	15.44	2.2	8.10	11.0	12.18	1.5	9.79	1.4	9.67	2.0
1.14	4.87	2.8	15.53	2.2	8.11	11.1	12.25	1.5	9.86	1.4	9.74	2.0
1.15	4.87	2.8	15.61	2.3	8.12	11.1	12.32	1.5	9.93	1.4	9.80	2.0
1.16	4.87	2.8	15.69	2.3	8.13	11.1	12.39	1.5	10.00	1.4	9.88	2.0
1.17	4.87	2.8	15.78	2.3	8.15	11.1	12.46	1.5	10.07	1.4	9.95	2.0
1.18	4.87	2.8	15.86	2.3	8.16	11.1	12.53	1.5	10.14	1.4	10.01	2.0
1.19	4.88	2.8	15.85	2.3	8.17	11.1	12.58	1.5	10.21	1.4	10.08	2.0
1.20	4.89	2.8	15.72	2.3	8.15	11.1	12.52	1.5	10.22	1.4	10.15	2.0
1.21	4.89	2.8	15.61	2.3	8.13	11.1	12.42	1.5	10.15	1.4	10.20	2.0
1.22	4.89	2.8	15.49	2.2	8.11	11.1	12.32	1.5	10.06	1.4	10.19	2.0
1.23	4.89	2.8	15.37	2.2	8.10	11.0	12.23	1.5	9.96	1.4	10.13	2.0
1.24	4.89	2.8	15.26	2.2	8.08	11.0	12.13	1.5	9.86	1.4	10.04	2.0
1.25	4.90	2.8	15.10	2.2	8.06	11.0	12.02	1.5	9.76	1.4	9.94	2.0
1.26	4.92	2.8	14.90	2.2	8.03	11.0	11.88	1.5	9.64	1.4	9.84	2.0
1.27	4.90	2.8	14.70	2.1	8.00	10.9	11.71	1.5	9.49	1.4	9.73	2.0
1.28	4.90	2.8	14.50	2.1	7.97	10.9	11.53	1.5	9.32	1.3	9.61	2.0
1.29	4.91	2.8	14.30	2.1	7.94	10.9	11.36	1.5	9.15	1.3	9.46	2.0
1.30	4.91	2.8	14.10	2.1	7.91	10.8	11.19	1.5	8.98	1.3	9.30	1.9
1.31	4.43	2.7	13.92	2.0	7.84	10.8	10.87	1.5	8.78	1.3	9.13	1.9
1.32	3.80	2.4	13.75	2.0	7.72	10.6	10.22	1.4	8.33	1.3	8.95	2.0
1.33	3.12	2.0	13.58	2.0	7.61	10.5	9.51	1.4	7.71	1.3	8.67	2.0
1.34	2.42	1.7	13.42	2.0	7.49	10.3	8.76	1.4	7.02	1.2	8.23	1.9
1.35	1.71	1.2	13.25	1.9	7.37	10.2	8.00	1.4	6.29	1.2	7.65	1.9
1.36	1.01	0.8	13.09	1.9	7.26	10.1	7.23	1.3	5.56	1.2	7.00	1.9
1.37	1.29	0.8	12.96	1.9	7.24	10.0	6.78	1.3	4.88	1.1	6.31	1.8
1.38	1.75	1.1	12.88	1.9	7.29	10.1	7.15	1.4	4.72	1.1	5.64	1.7
1.39	2.24	1.5	12.79	1.9	7.34	10.1	7.50	1.4	4.91	1.1	5.11	1.6
1.40	2.73	1.8	12.71	1.9	7.39	10.2	7.86	1.4	5.23	1.1	4.87	1.5
1.41	3.21	2.1	12.63	1.9	7.45	10.2	8.20	1.4	5.58	1.1	4.92	1.5
1.42	3.69	2.3	12.54	1.8	7.50	10.3	8.55	1.4	5.93	1.2	5.16	1.5
1.43	3.82	2.4	12.46	1.8	7.52	10.3	8.78	1.4	6.26	1.2	5.50	1.5
1.44	3.84	2.5	12.38	1.8	7.51	10.3	8.74	1.4	6.39	1.2	5.87	1.6
1.45	3.83	2.5	12.29	1.8	7.50	10.3	8.67	1.4	6.39	1.2	6.18	1.6
1.46	3.83	2.5	12.21	1.8	7.49	10.3	8.59	1.4	6.33	1.2	6.34	1.7
1.47	3.83	2.5	12.13	1.8	7.48	10.3	8.52	1.4	6.26	1.2	6.38	1.7
1.48	3.82	2.5	12.04	1.8	7.47	10.3	8.44	1.4	6.18	1.2	6.34	1.7
1.49	3.82	2.5	11.96	1.8	7.45	10.3	8.37	1.4	6.11	1.2	6.27	1.7
1.50	3.82	2.5	11.88	1.7	7.44	10.3	8.29	1.4	6.03	1.2	6.19	1.7
1.51	3.81	2.5	11.79	1.7	7.43	10.2	8.22	1.4	5.96	1.2	6.11	1.6
1.52	3.81	2.5	11.71	1.7	7.42	10.2	8.14	1.4	5.88	1.2	6.04	1.6
1.53	3.81	2.5	11.63	1.7	7.41	10.2	8.07	1.4	5.81	1.2	5.96	1.6
1.54	3.80	2.5	11.54	1.7	7.40	10.2	7.99	1.4	5.73	1.2	5.89	1.6
1.55	3.68	2.5	11.46	1.7	7.38	10.2	7.88	1.4	5.65	1.2	5.81	1.6
1.56	3.51	2.4	11.38	1.7	7.34	10.1	7.66	1.4	5.50	1.1	5.74	1.6
1.57	3.33	2.3	11.30	1.7	7.31	10.1	7.44	1.4	5.31	1.1	5.64	1.6
1.58	3.16	2.2	11.21	1.7	7.28	10.1	7.21	1.4	5.09	1.1	5.50	1.6
1.59	2.92	2.0	11.13	1.6	7.24	10.0	6.95	1.4	4.86	1.1	5.33	1.6

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

*************** TIME HISTORY OF FLOW AND VELOCITY ***************
Q(CFS), VEL(FPS)

TIME	CONDUIT 17		CONDUIT 19		CONDUIT 14		CONDUIT 12		CONDUIT 11		CONDUIT 1014	
HR , MIN	FLOW	VEL	FLOW	VEL	FLOW	VEL	FLOW	VEL	FLOW	VEL	FLOW	VEL
0.20	1.13	2.8	0.00	0.0	1.19	2.1	1.11	3.0	0.00	0.0	0.00	0.0
0.21	1.22	2.7	0.00	0.0	1.28	2.2	1.21	3.0	0.00	0.0	0.00	0.0
0.22	1.30	2.7	0.00	0.0	1.37	2.2	1.30	3.1	0.00	0.0	0.00	0.0
0.23	1.39	2.6	0.00	0.0	1.46	2.2	1.39	3.2	0.00	0.0	0.00	0.0
0.24	1.47	2.6	0.00	0.0	1.56	2.2	1.49	3.3	0.00	0.0	0.00	0.0
0.25	1.55	2.5	0.00	0.0	1.64	2.3	1.57	3.4	0.00	0.0	0.00	0.0
0.26	1.64	2.4	0.00	0.0	1.73	2.3	1.67	3.4	0.00	0.0	0.00	0.0
0.27	1.72	2.4	0.00	0.0	1.82	2.3	1.76	3.6	0.00	0.0	0.00	0.0
0.28	1.81	2.3	0.00	0.0	1.93	2.4	1.87	3.7	0.00	0.0	0.00	0.0
0.29	1.89	2.2	0.00	0.0	2.04	2.6	1.98	3.8	0.00	0.0	0.00	0.0
0.30	1.97	2.2	0.00	0.0	2.15	2.7	2.09	3.9	0.00	0.0	0.00	0.0
0.31	2.06	2.2	0.00	0.0	2.25	2.8	2.19	4.0	0.00	0.0	0.00	0.0
0.32	2.14	2.1	0.00	0.0	2.36	3.0	2.30	4.1	0.00	0.0	0.00	0.0
0.33	2.23	2.1	0.00	0.0	2.46	3.1	2.40	4.2	0.00	0.0	0.00	0.0
0.34	2.31	2.1	0.00	0.0	2.56	3.2	2.50	4.3	0.00	0.0	0.00	0.0
0.35	2.39	2.1	0.00	0.0	2.66	3.4	2.60	4.4	0.00	0.0	0.00	0.0
0.36	2.48	2.1	0.00	0.0	2.75	3.5	2.70	4.5	0.00	0.0	0.00	0.0
0.37	2.41	2.0	0.00	0.0	2.79	3.6	2.78	4.5	0.00	0.0	0.00	0.0
0.38	2.48	1.9	0.00	0.0	2.87	3.7	2.84	4.6	0.00	0.0	0.00	0.0
0.39	2.56	1.9	0.00	0.0	2.96	3.8	2.91	4.7	0.00	0.0	0.00	0.0
0.40	2.64	1.8	0.00	0.0	3.04	3.9	2.98	4.7	0.00	0.0	0.00	0.0
0.41	2.69	1.8	0.00	0.0	3.09	3.9	3.01	4.7	0.00	0.0	0.00	0.0
0.42	2.77	1.7	0.00	0.0	3.17	4.0	3.10	4.9	0.00	0.0	0.00	0.0
0.43	2.78	1.7	0.00	0.0	3.33	4.2	3.20	5.0	0.00	0.0	0.00	0.0
0.44	2.83	1.6	0.00	0.0	3.51	4.4	3.35	5.2	0.00	0.0	0.00	0.0
0.45	2.93	1.6	0.00	0.0	3.69	4.7	3.53	5.5	0.00	0.0	0.00	0.0
0.46	2.92	1.7	0.57	0.4	3.87	4.8	3.68	5.7	0.00	0.0	0.00	0.0
0.47	2.75	1.5	1.29	3.8	4.34	5.4	3.98	6.1	0.00	0.0	0.00	0.0
0.48	2.78	1.6	1.58	3.8	4.72	5.9	4.32	6.6	0.00	0.0	0.00	0.0
0.49	3.46	1.9	1.81	4.4	5.11	6.5	4.51	6.9	0.00	0.0	0.72	0.5
0.50	3.50	2.0	1.98	5.2	4.69	6.1	4.70	7.2	0.00	0.0	2.47	0.7
0.51	3.56	2.0	1.97	5.1	4.31	5.6	4.84	7.4	-0.00	0.0	3.32	0.5
0.52	3.64	2.1	1.96	5.1	3.97	5.1	4.96	7.5	-0.27	-0.3	3.96	0.4
0.53	3.66	2.1	1.95	5.1	3.64	4.7	5.06	7.7	-0.61	-0.5	4.51	0.4
0.54	3.71	2.1	1.95	5.1	3.35	4.3	5.14	7.8	-1.29	-0.7	5.01	0.5
0.55	3.79	2.1	1.94	5.0	3.14	4.0	5.20	7.9	-1.98	-1.0	5.66	0.5
0.56	3.82	2.2	1.93	5.0	2.97	3.8	5.26	8.0	-2.77	-1.1	6.96	0.6
0.57	3.87	2.2	1.91	5.0	2.76	3.6	5.33	8.1	-3.91	-1.3	8.48	0.8
0.58	3.96	2.2	1.90	4.9	2.56	3.3	5.38	8.1	-4.91	-1.5	8.60	0.8
0.59	4.04	2.3	1.89	4.9	2.56	3.2	5.40	8.2	-5.27	-1.5	8.42	0.8
1. 0	4.14	2.3	1.88	4.9	2.58	3.3	5.41	8.2	-5.43	-1.6	8.43	0.8
1. 1	4.19	2.4	1.88	4.9	2.61	3.3	5.42	8.2	-5.54	-1.6	8.49	0.8
1. 2	4.22	2.4	1.87	4.9	2.64	3.4	5.42	8.2	-5.64	-1.6	8.56	0.8
1. 3	4.25	2.4	1.87	4.9	2.67	3.4	5.43	8.2	-5.74	-1.6	8.63	0.8
1. 4	4.28	2.4	1.86	4.8	2.69	3.4	5.43	8.2	-5.84	-1.6	8.71	0.8
1. 5	4.32	2.4	1.86	4.8	2.72	3.5	5.44	8.2	-5.94	-1.6	8.78	0.8
1. 6	4.36	2.5	1.86	4.8	2.75	3.5	5.44	8.2	-6.03	-1.6	8.84	0.8

1, 7	4.41	2.5	1.85	4.8	2.75	3.5	5.44	8.2	-6.11	-1.6	8.89	0.8
1, 8	4.44	2.5	1.85	4.8	2.76	3.5	5.45	8.2	-6.17	-1.6	8.94	0.8
1, 9	4.48	2.5	1.85	4.8	2.76	3.5	5.45	8.2	-6.23	-1.6	8.99	0.8
1,10	4.51	2.6	1.85	4.8	2.77	3.5	5.45	8.3	-6.28	-1.6	9.02	0.8
1,11	4.55	2.6	1.85	4.8	2.77	3.5	5.45	8.3	-6.31	-1.7	9.03	0.8
1,12	4.58	2.6	1.85	4.8	2.78	3.5	5.45	8.3	-6.33	-1.7	9.03	0.8
1,13	4.60	2.6	1.85	4.8	2.78	3.5	5.45	8.3	-6.35	-1.7	9.04	0.8
1,14	4.60	2.6	1.85	4.8	2.78	3.5	5.45	8.3	-6.35	-1.7	9.04	0.8
1,15	4.60	2.6	1.85	4.8	2.78	3.5	5.45	8.3	-6.36	-1.7	9.05	0.8
1,16	4.60	2.6	1.85	4.8	2.78	3.5	5.45	8.3	-6.37	-1.7	9.06	0.8
1,17	4.60	2.6	1.85	4.8	2.78	3.5	5.46	8.3	-6.38	-1.7	9.07	0.8
1,18	4.60	2.6	1.85	4.8	2.78	3.5	5.46	8.3	-6.38	-1.7	9.07	0.8
1,19	4.59	2.6	1.85	4.8	2.77	3.5	5.46	8.3	-6.39	-1.7	9.08	0.8
1,20	4.57	2.6	1.85	4.8	2.77	3.5	5.46	8.3	-6.40	-1.7	9.09	0.8
1,21	4.56	2.6	1.85	4.8	2.77	3.5	5.46	8.3	-6.40	-1.7	9.09	0.8
1,22	4.54	2.6	1.85	4.8	2.77	3.5	5.46	8.3	-6.40	-1.7	9.09	0.8
1,23	4.52	2.6	1.85	4.8	2.76	3.5	5.46	8.3	-6.39	-1.7	9.08	0.8
1,24	4.51	2.6	1.85	4.8	2.76	3.5	5.46	8.3	-6.38	-1.7	9.06	0.8
1,25	4.49	2.5	1.85	4.8	2.76	3.5	5.45	8.3	-6.37	-1.7	9.05	0.8
1,26	4.48	2.5	1.85	4.8	2.75	3.5	5.45	8.3	-6.36	-1.7	9.04	0.8
1,27	4.46	2.5	1.85	4.8	2.75	3.5	5.45	8.3	-6.34	-1.7	9.03	0.8
1,28	4.44	2.5	1.85	4.8	2.75	3.5	5.45	8.3	-6.32	-1.7	9.01	0.8
1,29	4.43	2.5	1.85	4.8	2.74	3.5	5.45	8.3	-6.30	-1.7	8.99	0.8
1,30	4.43	2.5	1.85	4.8	2.73	3.5	5.45	8.3	-6.28	-1.6	8.97	0.8
1,31	4.49	2.5	1.86	4.8	2.63	3.4	5.45	8.2	-6.21	-1.6	8.88	0.8
1,32	4.47	2.5	1.88	4.9	2.53	3.2	5.44	8.2	-6.09	-1.6	8.83	0.8
1,33	4.45	2.5	1.89	4.9	2.44	3.1	5.43	8.2	-5.96	-1.6	8.76	0.8
1,34	4.43	2.5	1.90	4.9	2.35	3.0	5.42	8.2	-5.81	-1.6	8.66	0.8
1,35	4.41	2.5	1.91	5.0	2.27	2.9	5.41	8.2	-5.64	-1.6	8.54	0.8
1,36	4.37	2.5	1.92	5.0	2.20	2.8	5.41	8.2	-5.45	-1.6	8.39	0.8
1,37	4.24	2.4	1.91	5.0	2.29	2.9	5.40	8.2	-5.34	-1.5	8.39	0.8
1,38	4.24	2.4	1.91	5.0	2.34	3.0	5.40	8.2	-5.31	-1.5	8.35	0.8
1,39	4.22	2.4	1.90	4.9	2.40	3.0	5.40	8.2	-5.30	-1.5	8.32	0.8
1,40	4.19	2.4	1.90	4.9	2.45	3.1	5.40	8.2	-5.32	-1.5	8.33	0.8
1,41	4.16	2.4	1.89	4.9	2.51	3.2	5.41	8.2	-5.39	-1.5	8.40	0.8
1,42	4.15	2.3	1.88	4.9	2.57	3.3	5.41	8.2	-5.48	-1.6	8.48	0.8
1,43	4.19	2.4	1.88	4.9	2.56	3.3	5.42	8.2	-5.56	-1.6	8.50	0.8
1,44	4.16	2.4	1.88	4.9	2.56	3.3	5.42	8.2	-5.61	-1.6	8.54	0.8
1,45	4.15	2.3	1.88	4.9	2.56	3.3	5.42	8.2	-5.66	-1.6	8.57	0.8
1,46	4.13	2.3	1.88	4.9	2.55	3.3	5.42	8.2	-5.69	-1.6	8.58	0.8
1,47	4.12	2.3	1.88	4.9	2.55	3.2	5.42	8.2	-5.70	-1.6	8.58	0.8
1,48	4.11	2.3	1.88	4.9	2.55	3.2	5.42	8.2	-5.70	-1.6	8.56	0.8
1,49	4.09	2.3	1.88	4.9	2.54	3.2	5.42	8.2	-5.69	-1.6	8.55	0.8
1,50	4.07	2.3	1.88	4.9	2.54	3.2	5.42	8.2	-5.67	-1.6	8.54	0.8
1,51	4.06	2.3	1.88	4.9	2.54	3.2	5.42	8.2	-5.66	-1.6	8.53	0.8
1,52	4.04	2.3	1.88	4.9	2.54	3.2	5.42	8.2	-5.65	-1.6	8.51	0.8
1,53	4.02	2.3	1.88	4.9	2.53	3.2	5.42	8.2	-5.63	-1.6	8.50	0.8
1,54	4.01	2.3	1.89	4.9	2.53	3.2	5.42	8.2	-5.62	-1.6	8.49	0.8
1,55	4.02	2.3	1.89	4.9	2.50	3.2	5.42	8.2	-5.59	-1.6	8.46	0.8
1,56	4.00	2.3	1.89	4.9	2.47	3.2	5.41	8.2	-5.55	-1.6	8.44	0.8
1,57	3.98	2.3	1.89	4.9	2.45	3.1	5.41	8.2	-5.51	-1.6	8.41	0.8
1,58	3.96	2.2	1.90	4.9	2.43	3.1	5.41	8.2	-5.47	-1.6	8.38	0.8
1,59	3.95	2.2	1.90	4.9	2.40	3.1	5.41	8.2	-5.41	-1.6	8.34	0.8

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

*************** TIME HISTORY OF FLOW AND VELOCITY ***************
Q(CFS), VEL(FPS)

TIME	CONDUIT 9012		CONDUIT 9018		CONDUIT 9036		CONDUIT 9029		CONDUIT
0.20	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.21	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.22	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.23	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.24	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.25	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.26	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.27	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.28	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.29	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.30	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.31	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.32	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.33	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.34	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.35	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.36	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.37	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.38	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.39	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.40	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.41	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
0.42	0.00	0.0	0.00	0.0	0.00	0.0	-0.41	-0.2	
0.43	0.00	0.0	0.00	0.0	0.00	0.0	-0.28	-0.2	
0.44	0.00	0.0	0.00	0.0	0.01	0.3	-0.78	-0.2	
0.45	0.00	0.0	-0.22	0.0	1.22	3.2	-1.42	-0.5	
0.46	0.00	0.0	-0.39	-0.1	1.67	3.0	-1.94	-0.7	
0.47	0.00	0.0	-0.45	-0.2	2.17	2.5	-2.40	-0.9	
0.48	0.00	0.0	-0.50	-0.1	2.66	2.1	-2.86	-1.0	
0.49	-0.44	-0.2	-2.04	-0.6	3.12	1.7	-3.30	-1.2	
0.50	0.20	0.1	-2.92	-0.9	3.03	1.5	-3.76	-1.4	
0.51	0.70	0.2	-3.51	-1.1	2.33	0.9	-4.22	-1.5	
0.52	1.14	0.4	-4.11	-1.3	2.40	0.9	-4.74	-1.7	
0.53	1.55	0.6	-4.63	-1.5	2.33	0.9	-5.20	-1.9	
0.54	1.89	0.7	-5.13	-1.6	2.33	0.8	-5.61	-2.0	
0.55	2.14	0.8	-5.57	-1.8	2.33	0.8	-6.08	-2.2	
0.56	2.39	0.8	-5.92	-1.9	2.33	0.8	-6.58	-2.4	
0.57	2.67	0.9	-6.33	-2.0	2.34	0.8	-7.12	-2.5	
0.58	2.87	1.0	-6.77	-2.2	2.34	0.8	-7.54	-2.7	
0.59	2.87	1.0	-7.04	-2.2	2.34	0.8	-8.02	-2.9	
1. 0	2.84	1.0	-7.29	-2.3	2.34	0.8	-8.52	-3.0	
1. 1	2.82	1.0	-7.47	-2.4	2.34	0.8	-9.02	-3.2	
1. 2	2.79	1.0	-7.63	-2.4	2.34	0.8	-9.49	-3.4	
1. 3	2.77	1.0	-7.80	-2.5	2.34	0.8	-9.95	-3.5	
1. 4	2.75	1.0	-7.96	-2.5	2.34	0.8	-10.41	-3.7	
1. 5	2.72	0.9	-8.12	-2.6	2.35	0.8	-10.88	-3.9	
1. 6	2.70	0.9	-8.28	-2.6	2.35	0.8	-11.34	-4.0	
1. 7	2.70	0.9	-8.33	-2.7	2.35	0.8	-11.71	-4.2	

1, 8	2.69	0.9	-8.35	-2.7	2.34	0.8	-11.84	-4.2
1, 9	2.69	0.9	-8.38	-2.7	2.34	0.8	-11.91	-4.2
1.10	2.69	0.9	-8.41	-2.7	2.34	0.8	-11.98	-4.3
1.11	2.68	0.9	-8.43	-2.7	2.34	0.8	-12.05	-4.3
1.12	2.68	0.9	-8.46	-2.7	2.34	0.8	-12.12	-4.3
1.13	2.68	0.9	-8.48	-2.7	2.34	0.8	-12.19	-4.3
1.14	2.68	0.9	-8.47	-2.7	2.34	0.8	-12.26	-4.4
1.15	2.68	0.9	-8.47	-2.7	2.34	0.8	-12.33	-4.4
1.16	2.68	0.9	-8.46	-2.7	2.34	0.8	-12.40	-4.4
1.17	2.68	0.9	-8.46	-2.7	2.34	0.8	-12.47	-4.4
1.18	2.68	0.9	-8.46	-2.7	2.34	0.8	-12.54	-4.4
1.19	2.68	0.9	-8.45	-2.7	2.34	0.8	-12.58	-4.5
1.20	2.68	0.9	-8.43	-2.7	2.34	0.8	-12.51	-4.4
1.21	2.69	0.9	-8.41	-2.7	2.34	0.8	-12.41	-4.4
1.22	2.69	0.9	-8.40	-2.7	2.34	0.8	-12.31	-4.4
1.23	2.69	0.9	-8.38	-2.7	2.34	0.8	-12.21	-4.3
1.24	2.70	0.9	-8.37	-2.7	2.34	0.8	-12.11	-4.3
1.25	2.70	0.9	-8.35	-2.7	2.34	0.8	-12.00	-4.3
1.26	2.70	0.9	-8.34	-2.7	2.33	0.8	-11.85	-4.2
1.27	2.70	0.9	-8.32	-2.7	2.33	0.8	-11.67	-4.2
1.28	2.70	0.9	-8.31	-2.7	2.33	0.8	-11.50	-4.1
1.29	2.71	0.9	-8.29	-2.6	2.33	0.8	-11.33	-4.0
1.30	2.71	0.9	-8.25	-2.6	2.33	0.8	-11.16	-4.0
1.31	2.80	1.0	-7.77	-2.5	2.33	0.8	-10.76	-3.9
1.32	2.89	1.0	-7.18	-2.3	2.32	0.8	-10.09	-3.7
1.33	2.98	1.0	-6.59	-2.1	2.31	0.8	-9.36	-3.4
1.34	3.05	1.1	-6.00	-2.0	2.30	0.8	-8.61	-3.1
1.35	3.13	1.1	-5.41	-1.8	2.30	0.8	-7.84	-2.9
1.36	3.20	1.1	-4.85	-1.6	2.29	0.8	-7.07	-2.6
1.37	3.12	1.1	-5.14	-1.6	2.30	0.8	-6.86	-2.5
1.38	3.06	1.1	-5.58	-1.8	2.32	0.8	-7.22	-2.6
1.39	3.01	1.1	-5.99	-1.9	2.33	0.8	-7.58	-2.7
1.40	2.96	1.0	-6.39	-2.0	2.33	0.8	-7.93	-2.8
1.41	2.91	1.0	-6.79	-2.2	2.33	0.8	-8.27	-3.0
1.42	2.85	1.0	-7.17	-2.3	2.33	0.8	-8.62	-3.1
1.43	2.86	1.0	-7.21	-2.3	2.33	0.8	-8.78	-3.2
1.44	2.87	1.0	-7.19	-2.3	2.33	0.8	-8.73	-3.1
1.45	2.87	1.0	-7.17	-2.3	2.32	0.8	-8.65	-3.1
1.46	2.87	1.0	-7.16	-2.3	2.32	0.8	-8.58	-3.1
1.47	2.87	1.0	-7.15	-2.3	2.32	0.8	-8.50	-3.1
1.48	2.87	1.0	-7.13	-2.3	2.32	0.8	-8.43	-3.0
1.49	2.88	1.0	-7.12	-2.3	2.32	0.8	-8.35	-3.0
1.50	2.88	1.0	-7.10	-2.3	2.32	0.8	-8.28	-3.0
1.51	2.88	1.0	-7.09	-2.3	2.32	0.8	-8.20	-3.0
1.52	2.88	1.0	-7.07	-2.3	2.32	0.8	-8.13	-2.9
1.53	2.89	1.0	-7.05	-2.3	2.32	0.8	-8.05	-2.9
1.54	2.89	1.0	-7.03	-2.3	2.32	0.8	-7.97	-2.9
1.55	2.91	1.0	-6.89	-2.2	2.32	0.8	-7.83	-2.8
1.56	2.94	1.0	-6.73	-2.2	2.31	0.8	-7.62	-2.8
1.57	2.96	1.0	-6.57	-2.1	2.31	0.8	-7.39	-2.7
1.58	2.98	1.0	-6.42	-2.1	2.31	0.8	-7.16	-2.6
1.59	3.00	1.0	-6.26	-2.0	2.31	0.8	-6.88	-2.5

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

''''''''''''''''''' SUMMARY STATISTICS FOR CONDUITS '''''''''''''''''''

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1	979.6	2.7	120.0	349.5	2	0	3.4	2	0	0.4	4.27	4.10
2	979.6	2.7	120.0	348.7	2	0	3.6	2	0	0.4	4.10	3.88
3	979.6	2.7	120.0	286.4	2	0	3.2	2	0	0.3	3.88	3.71
4	979.6	2.7	120.0	285.7	2	0	3.4	2	0	0.3	3.71	3.50
5	979.6	2.7	120.0	285.1	2	0	3.8	2	0	0.3	3.50	3.19
6	979.6	2.7	120.0	284.5	2	0	5.2	2	0	0.3	3.19	1.96
7	63.3	4.2	36.0	6.1	1	10	0.6	0	1	0.1	3.00	3.88
8	632.8	42.2	36.0	6.8	1	21	1.2	1	0	0.0	0.25	3.00
9	228.3	14.3	24.0	6.4	1	22	5.3	1	22	0.0	0.78	0.25
10	174.4	10.9	24.0	6.4	1	22	3.4	1	21	0.0	0.58	0.78
11	93.2	5.8	24.0	0.0	0	0	0.0	0	0	0.0	0.58	1.31
35	64.8	7.8	19.2	13.6	1	21	4.7	1	21	0.2	0.75	0.85
34	30.2	7.5	12.0	5.5	1	22	3.0	1	39	0.2	0.41	0.75
13	32.9	8.2	12.0	5.5	1	22	4.8	1	22	0.2	0.39	0.41
12	1.8	2.3	12.0	5.5	1	22	8.3	1	22	3.1	4.58	0.39
14	2.7	3.4	12.0	5.1	0	49	6.5	0	49	1.9	4.61	4.58
17	11.8	6.7	18.0	4.6	1	13	2.9	0	1	0.4	3.76	4.61
16	15.8	8.9	18.0	4.6	1	13	7.5	0	1	0.3	0.96	3.76
15	18.2	10.3	18.0	4.6	1	13	21.8	0	0	0.3	0.51	0.96
19	2.4	6.2	8.4	2.0	0	50	5.2	0	50	0.8	3.00	4.61
21	2.1	5.4	8.4	2.3	1	20	6.1	1	20	1.1	3.85	3.00
24	2.7	6.9	8.4	2.3	1	20	29.0	0	44	0.9	2.70	3.85
26	1.7	4.4	8.4	2.5	0	49	6.6	0	50	1.5	3.62	2.70
18	64.8	7.8	19.2	8.2	1	21	3.7	1	21	0.1	0.58	0.75
20	58.0	7.0	19.2	8.2	1	21	4.1	1	21	0.1	0.65	0.58
22	41.0	4.9	19.2	8.2	1	20	3.3	1	20	0.2	0.80	0.65
23	82.0	9.9	19.2	8.2	1	20	3.7	1	20	0.1	0.51	0.80
25	29.0	3.5	19.2	8.2	1	20	2.8	1	20	0.3	1.09	0.51
27	45.8	5.5	19.2	8.2	1	19	2.4	1	19	0.2	0.69	1.09
30	4.0	5.1	12.0	8.2	1	19	11.1	1	19	2.0	5.31	0.69
29	18.2	10.3	18.0	4.9	1	27	2.8	1	30	0.3	1.60	5.31
28	12.9	7.3	18.0	4.9	1	6	6.2	0	58	0.4	0.64	1.60
31	71.0	8.5	19.2	15.9	1	19	2.3	1	19	0.2	0.78	5.31
32	58.0	7.0	19.2	15.9	1	18	4.9	1	19	0.3	0.95	0.78
33	64.8	7.8	19.2	15.9	1	18	12.9	0	0	0.2	0.81	0.95
1014	29.1	2.3	6.0	9.1	1	21	1.2	0	50	0.3	0.42	1.31
1019	19.1	2.6	6.0	10.2	1	22	2.0	1	22	0.5	0.39	0.42
1021	93.5	4.7	12.0	10.2	1	21	2.7	1	21	0.1	0.48	0.39

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ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM

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1024	35.2	3.1	6.0	10.2	1	20	10.9	0	49	0.3	0.31	0.48
1026	25.6	1.3	12.0	10.2	1	20	1.4	1	20	0.4	0.84	0.31
1036	122.3	3.6	18.0	12.6	1	19	1.7	0	52	0.1	0.64	0.84
9012	26.7	8.5	24.0	3.2	1	36	1.1	1	36	0.1	1.31	4.58
9018	31.0	9.9	24.0	0.0	0	0	0.0	0	0	0.0	1.92	4.61
9029	25.5	8.1	24.0	0.0	0	0	0.0	0	0	0.0	1.14	5.31
9036	22.3	7.1	24.0	3.5	0	50	3.7	0	45	0.2	1.34	3.62

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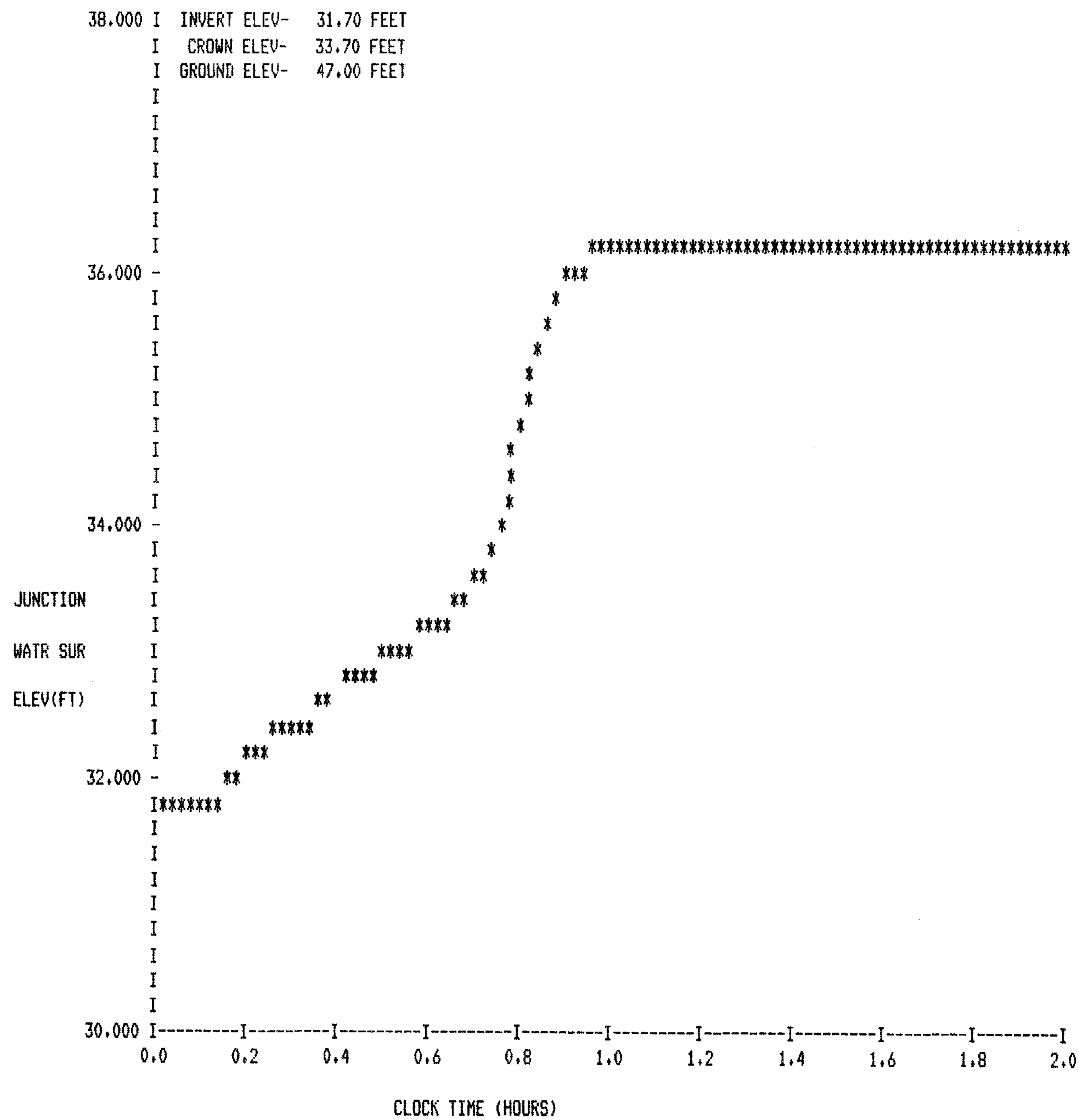
ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



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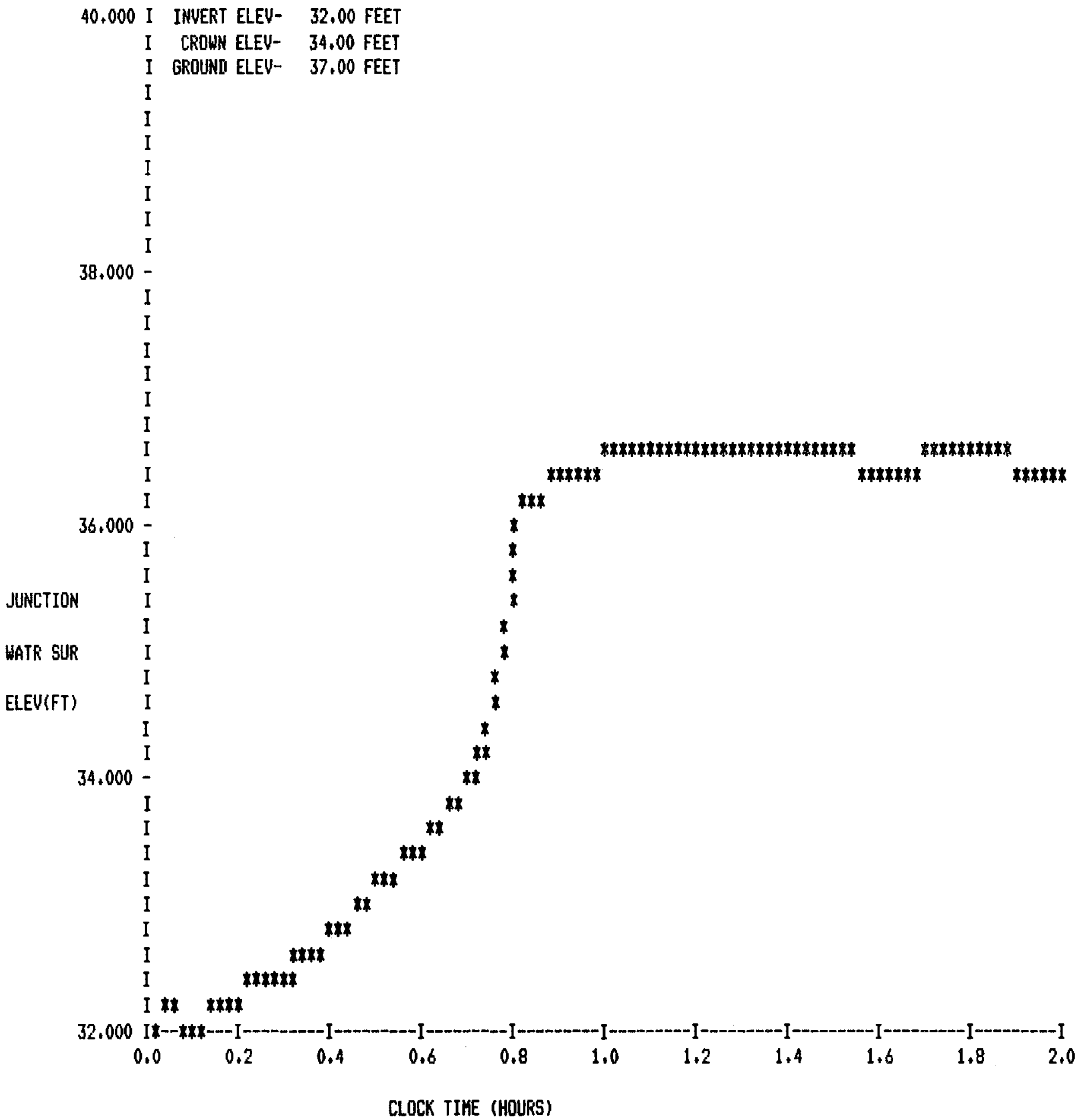

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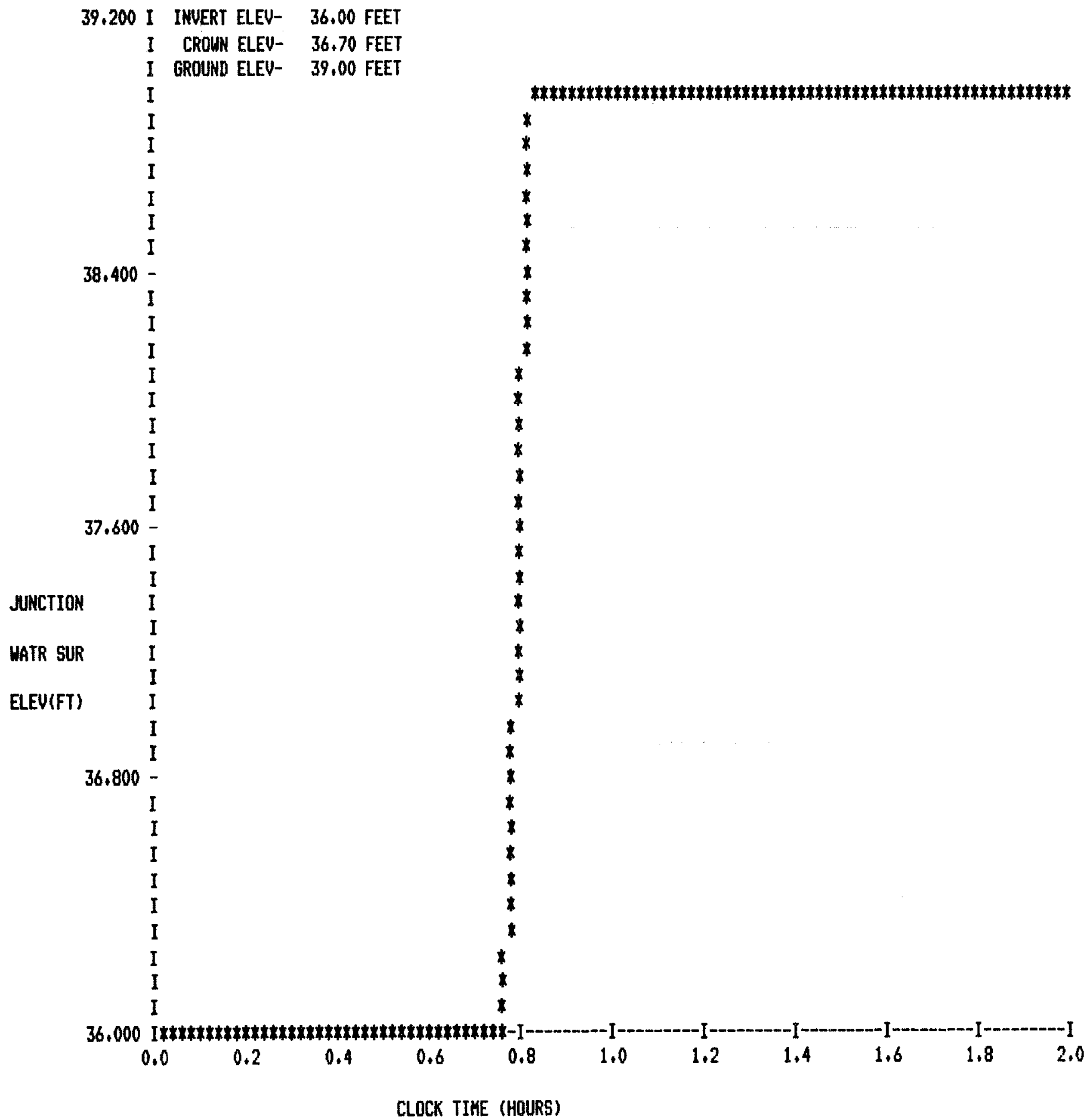
ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



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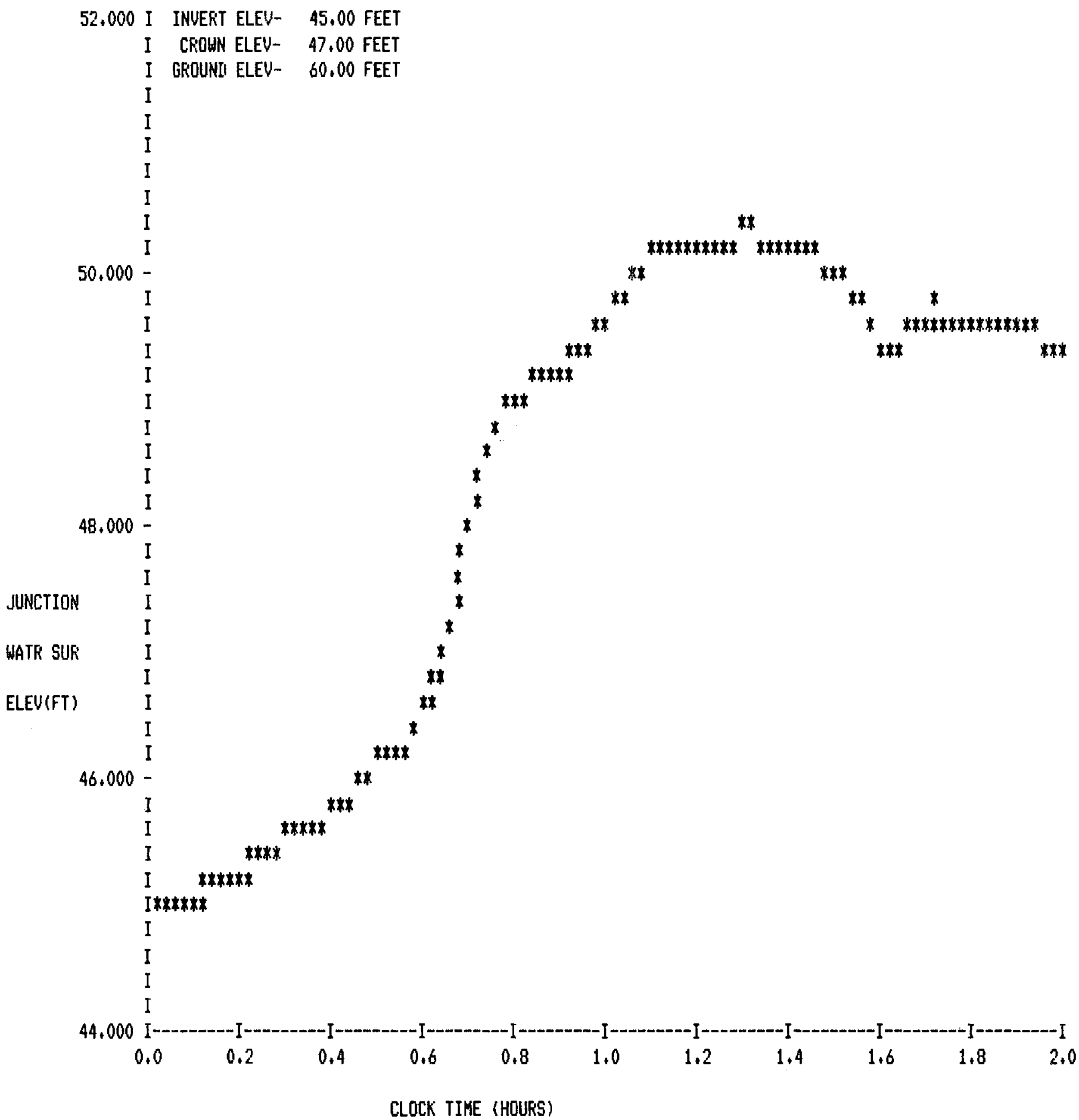
ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



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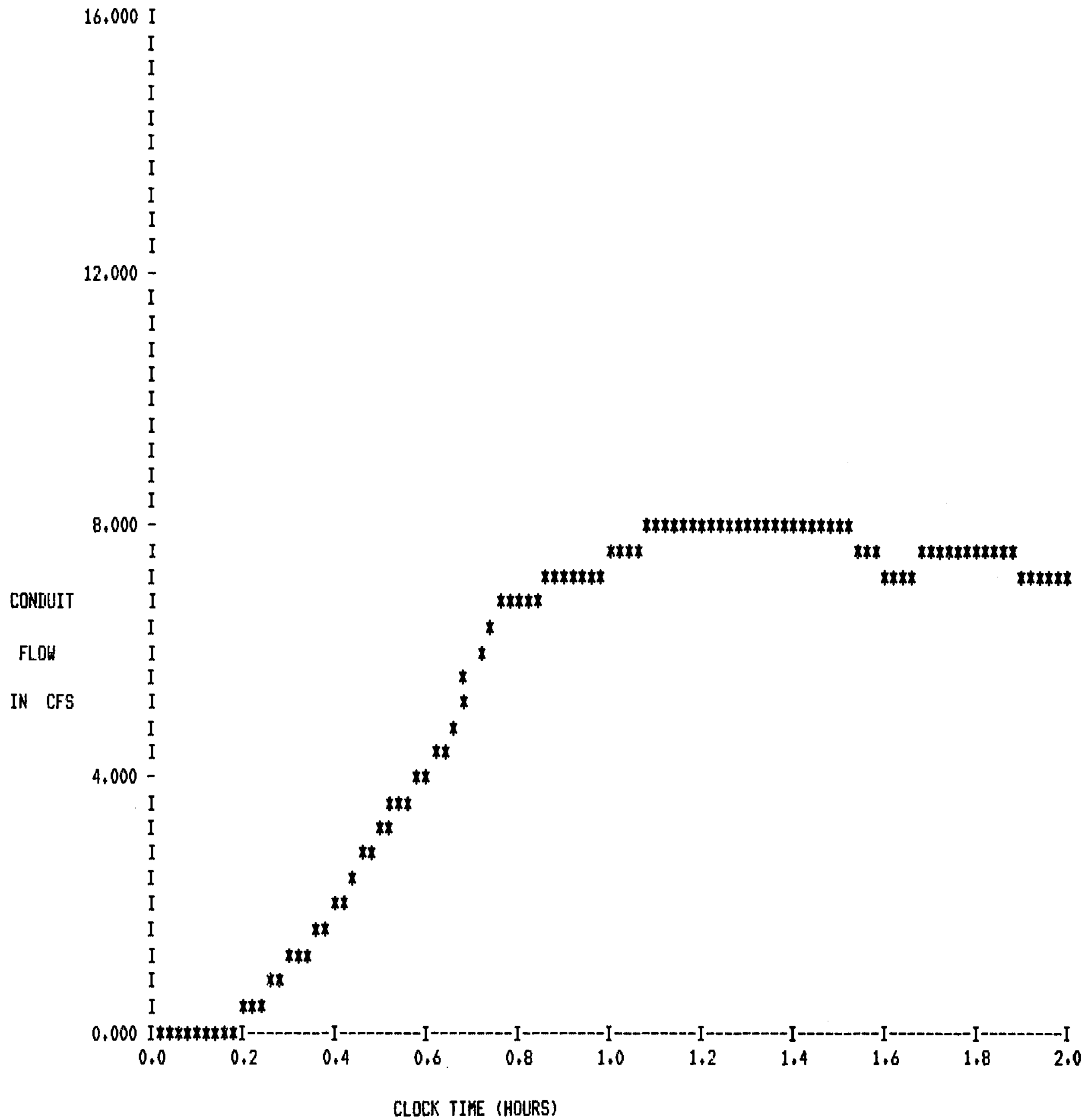

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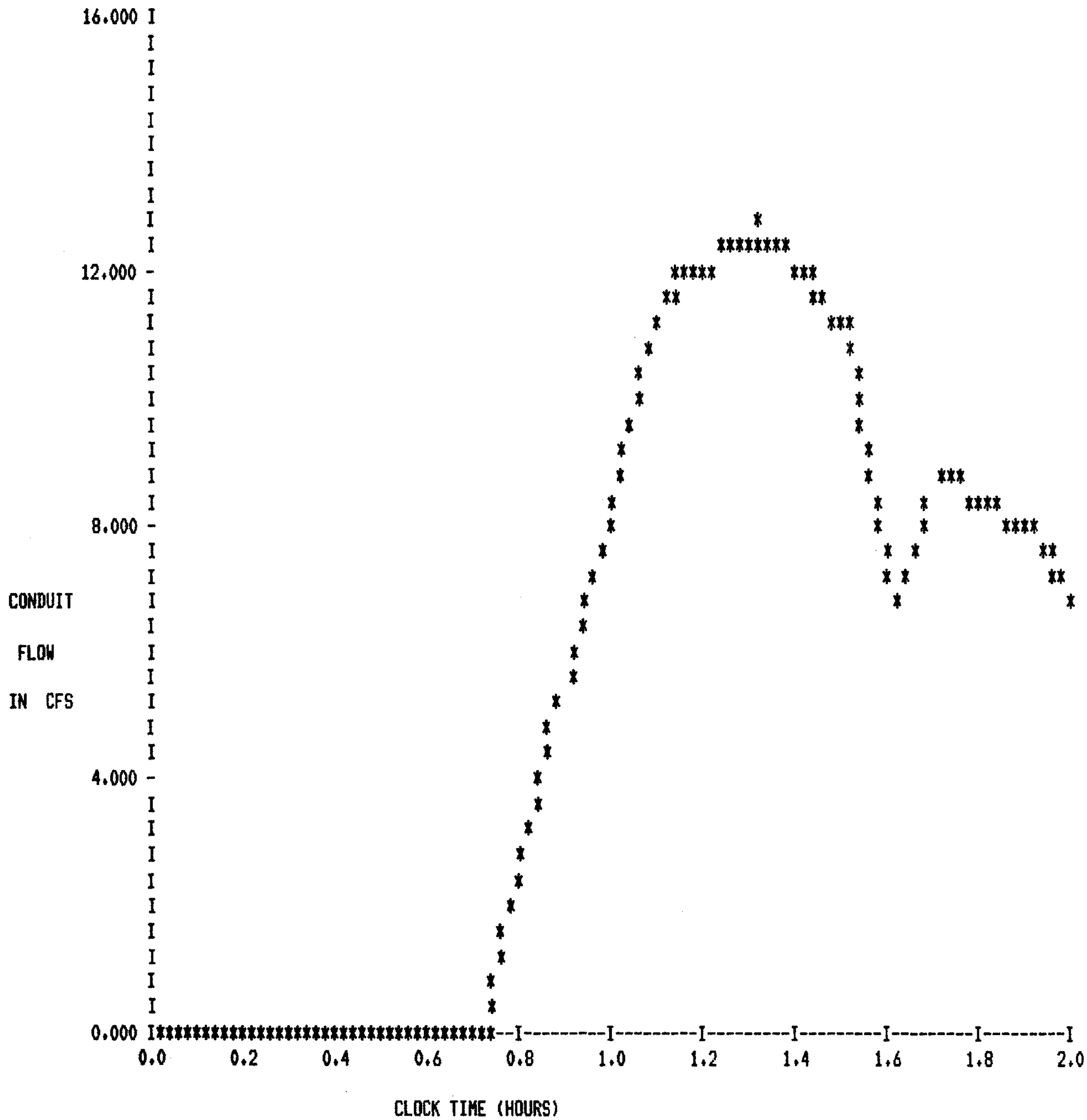
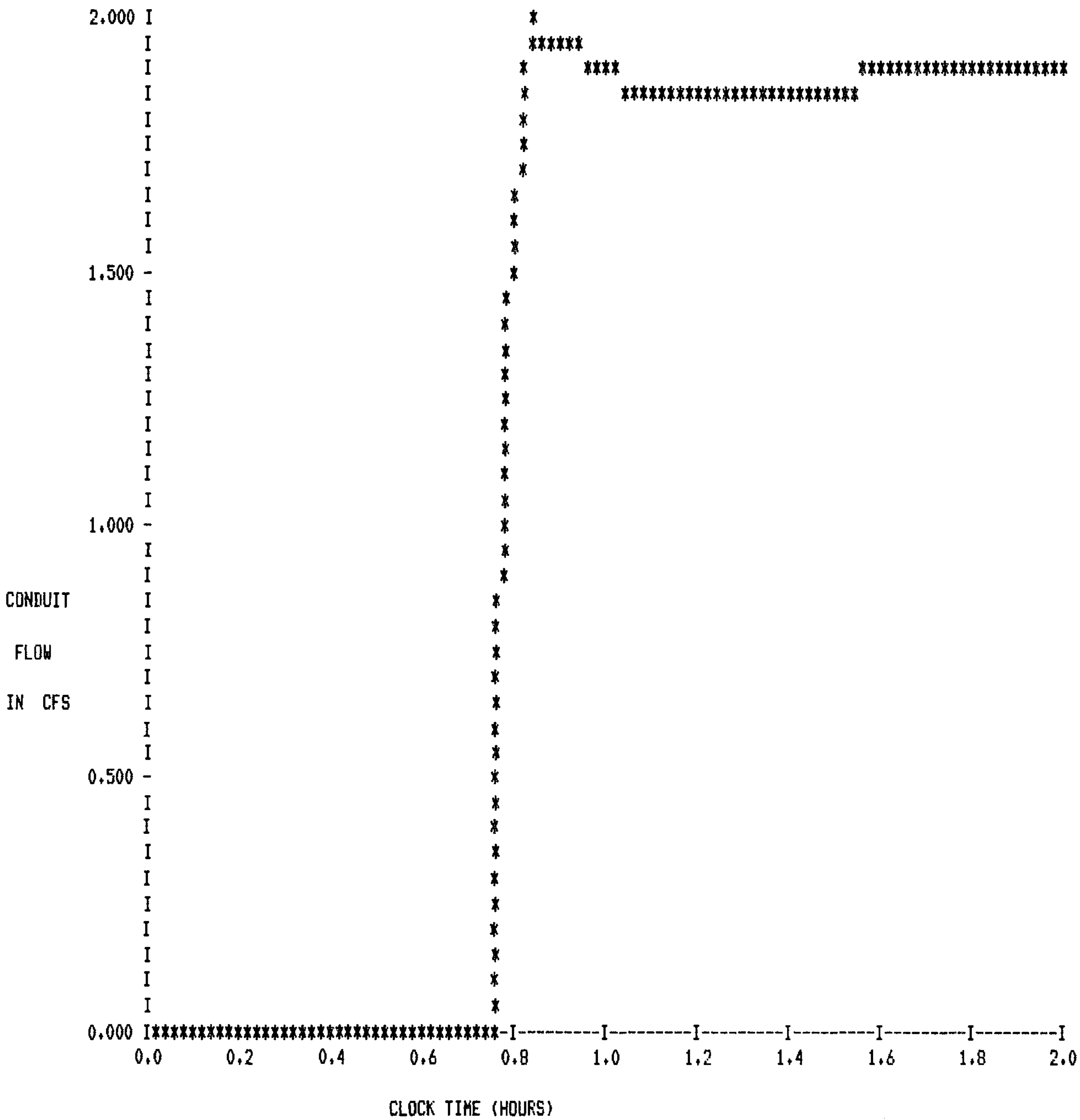
DEPARTMENT OF TRANSPORTATION **** **** CAMP DRESSER & MCKEE INC.
WASHINGTON, D.C. **** ANALYSIS MODULE **** ANNANDALE, VIRGINIA

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



CONDUIT NUMBER 1036

ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



CONDUIT NUMBER 19

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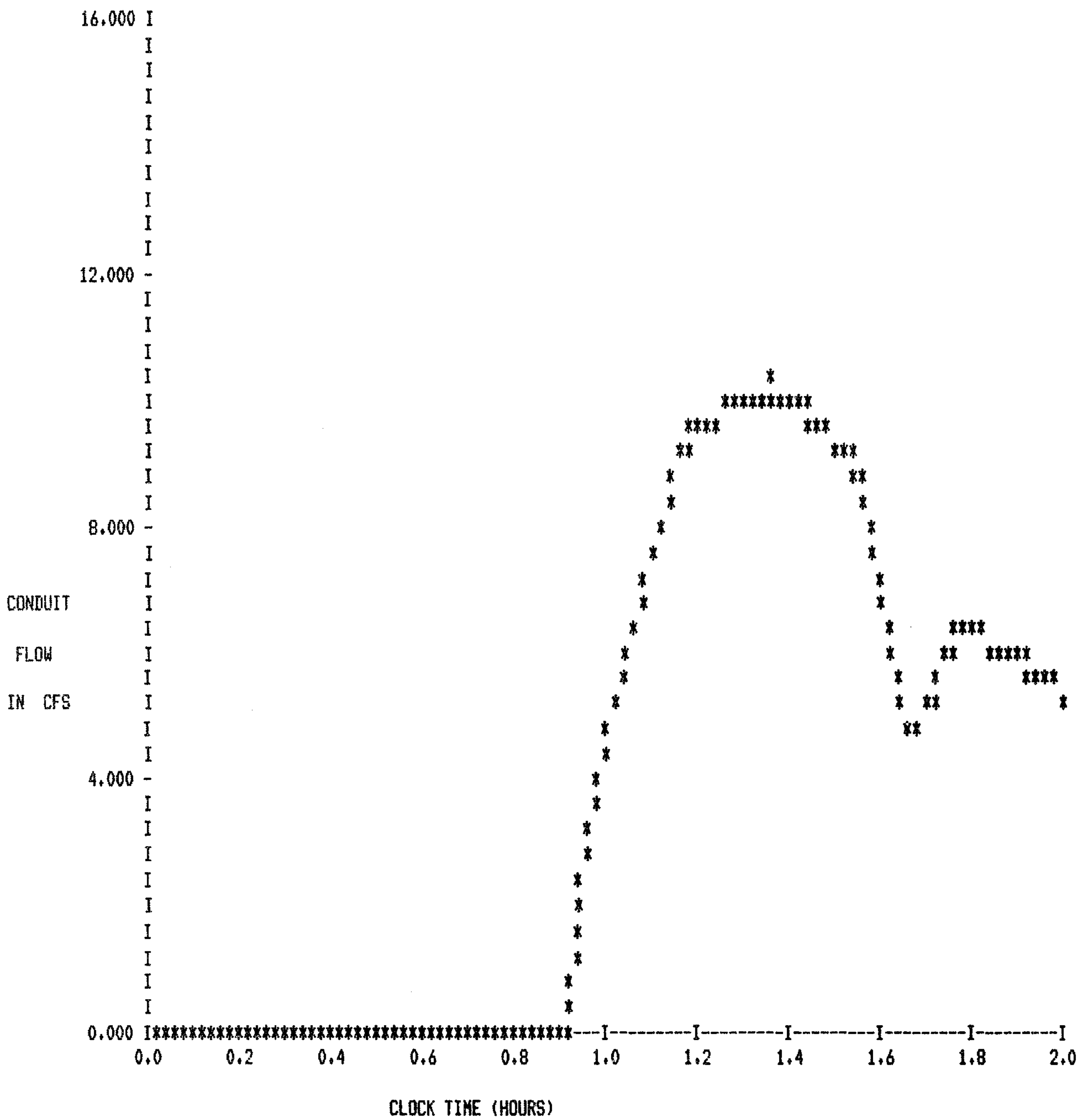
ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



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FEDERAL HIGHWAY ADMINISTRATION **** URBAN HIGHWAY DRAINAGE PROGRAM **** WATER RESOURCES DIVISION
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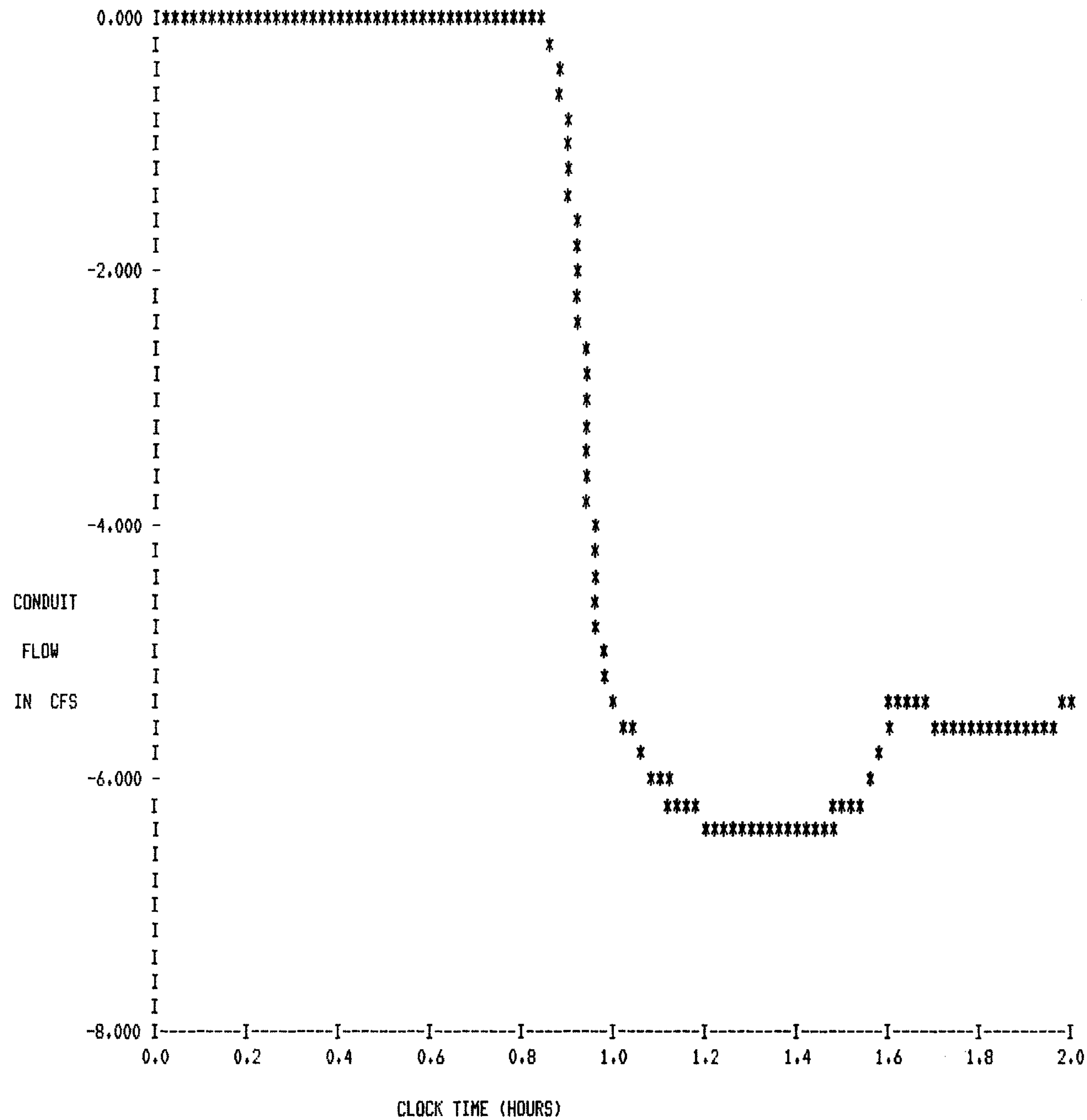
ANALYSIS MODULE EXAMPLE PROBLEM
BELLVIEW REDMOND ROAD DRAINAGE SYSTEM



CONDUIT NUMBER 11

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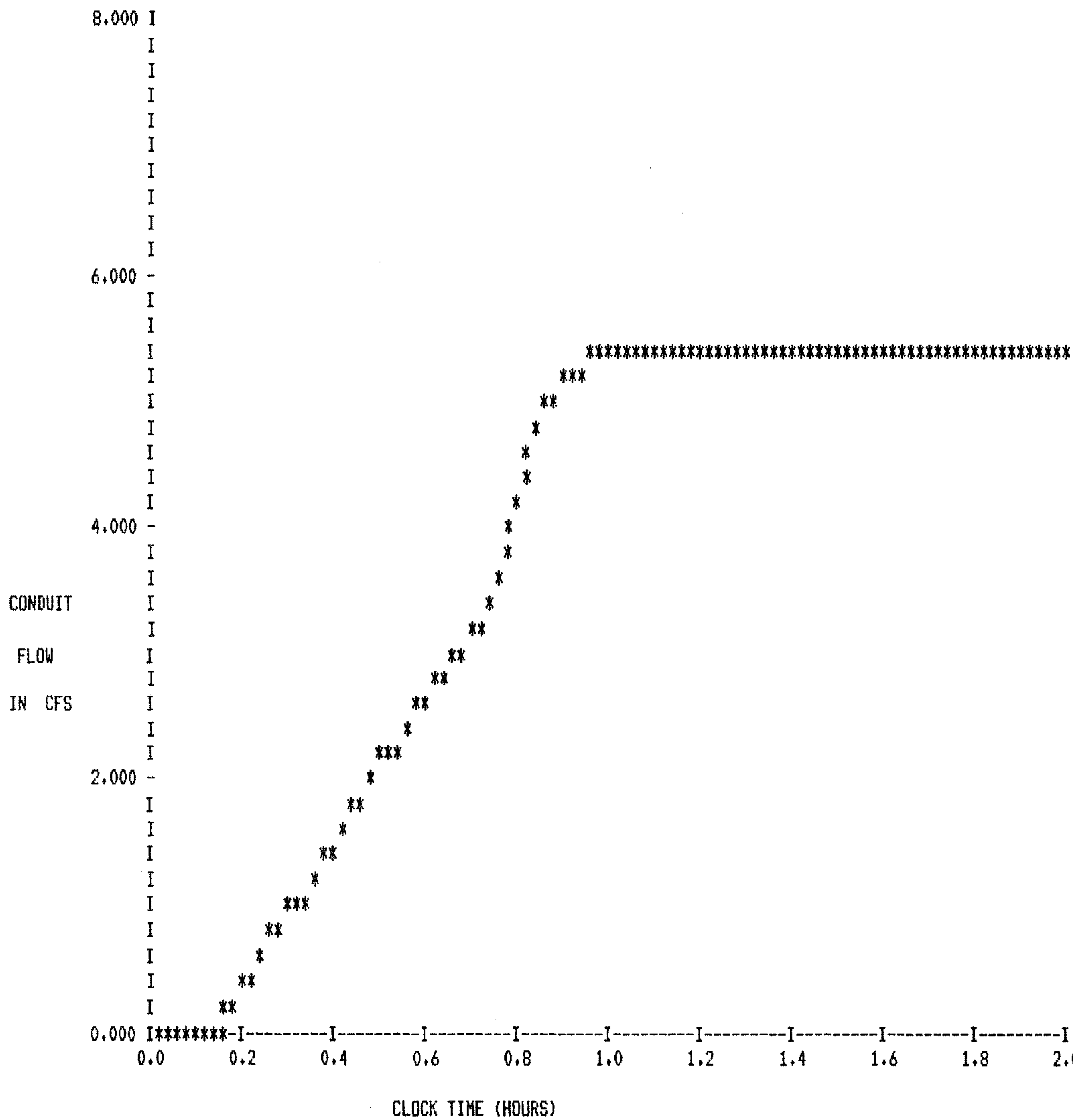

CONDUIT NUMBER 12

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FEDERALLY COORDINATED PROGRAM (FCP) OF HIGHWAY RESEARCH AND DEVELOPMENT

The Offices of Research and Development (R&D) of the Federal Highway Administration (FHWA) are responsible for a broad program of staff and contract research and development and a Federal-aid program, conducted by or through the State highway transportation agencies, that includes the Highway Planning and Research (HP&R) program and the National Cooperative Highway Research Program (NCHRP) managed by the Transportation Research Board. The FCP is a carefully selected group of projects that uses research and development resources to obtain timely solutions to urgent national highway engineering problems.*

The diagonal double stripe on the cover of this report represents a highway and is color-coded to identify the FCP category that the report falls under. A red stripe is used for category 1, dark blue for category 2, light blue for category 3, brown for category 4, gray for category 5, green for categories 6 and 7, and an orange stripe identifies category 0.

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems associated with the responsibilities of the FHWA under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion, and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by balancing the demand-capacity relationship through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements that affect the quality of the human environment. The goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge and technology of materials properties, using available natural materials, improving structural foundation materials, recycling highway materials, converting industrial wastes into useful highway products, developing extender or substitute materials for those in short supply, and developing more rapid and reliable testing procedures. The goals are lower highway construction costs and extended maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural and hydraulic designs, fabrication processes, and construction techniques to provide safe, efficient highways at reasonable costs.

6. Improved Technology for Highway Construction

This category is concerned with the research, development, and implementation of highway construction technology to increase productivity, reduce energy consumption, conserve dwindling resources, and reduce costs while improving the quality and methods of construction.

7. Improved Technology for Highway Maintenance

This category addresses problems in preserving the Nation's highways and includes activities in physical maintenance, traffic services, management, and equipment. The goal is to maximize operational efficiency and safety to the traveling public while conserving resources.

0. Other New Studies

This category, not included in the seven-volume official statement of the FCP, is concerned with HP&R and NCHRP studies not specifically related to FCP projects. These studies involve R&D support of other FHWA program office research.

* The complete seven-volume official statement of the FCP is available from the National Technical Information Service, Springfield, Va. 22161. Single copies of the introductory volume are available without charge from Program Analysis (HRD-3), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.

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